



Superpave For Airports

Federal Aviation Administration
Northwest Mountain Region Annual Conference
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Presentation Overview

- Introduction—Why Superpave?
- Current HMA Airfield Paving Specifications
- Superpave Overview
- Superpave Case Studies at US Airports

Desirable Properties of HMA

“The final goal of mix design is to...achieve a balance among all the desired [mix] properties.” (MS-22)

Seven Desirable Properties of HMA

- Stability
- Durability
- Impermeability
- Workability
- Flexibility
- Fatigue Resistance
- Skid Resistance

Marshall Mix Design Method

- Developed by Bruce Marshall, MissDOT Bituminous Engr
- Adopted by Corps of Engineers--WWII
- Adopted by FAA as Basis of P-401--1950s
- ASTM D 1559



Mix Design in the 1940s

- Impact Hammer
 - 10 lbs
 - 18" Drop
- Compact with 50 or 75 blows per side depending on aircraft weight
 - $> 60\text{k lbs} = 75$
 - $< 60\text{k lbs} = 50$



Airport Paving in the 1940s



Airport Paving in the 21st Century



777-300ER Max Gross Weight: 750,000 lbs
Main Gear Tire Pressure: 218 psi



Photo Courtesy Andrew Hunt/Airliner.net—Technical Data Source: Boeing

Beechcraft King Air B-200: Max Wt 12,500 lbs

Tire Pressure: 150 psi



Photo Courtesy North Carolina DOT—Data Source: Raytheon



Most airfield pavements are very infrequently loaded—lack of kneading action accelerates aging and leads to “Block Cracking”



Block (Environmental) Cracking on Overrun

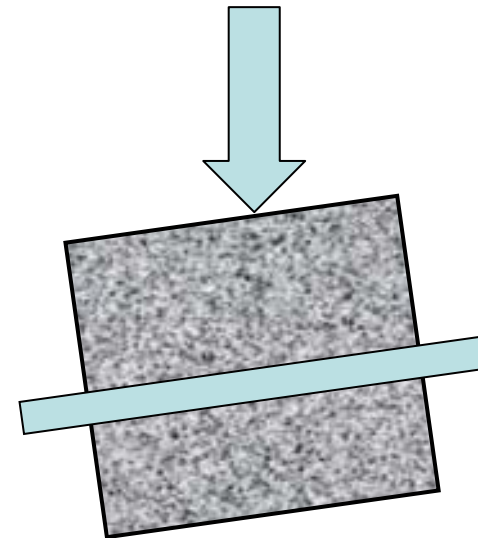
A large military aircraft, possibly a bomber, is shown from a low angle on a runway. A high-pressure water spray is directed upwards from the ground towards the aircraft's landing gear. The background features a line of green trees under a clear sky.

Deterioration of Airfield Pavements Can Lead to Foreign Object Damage (FOD) of Jet Engines

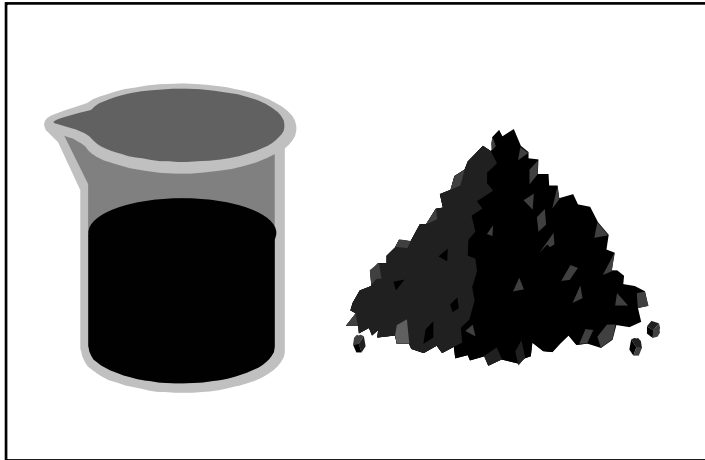
Mix Design in the 21st Century



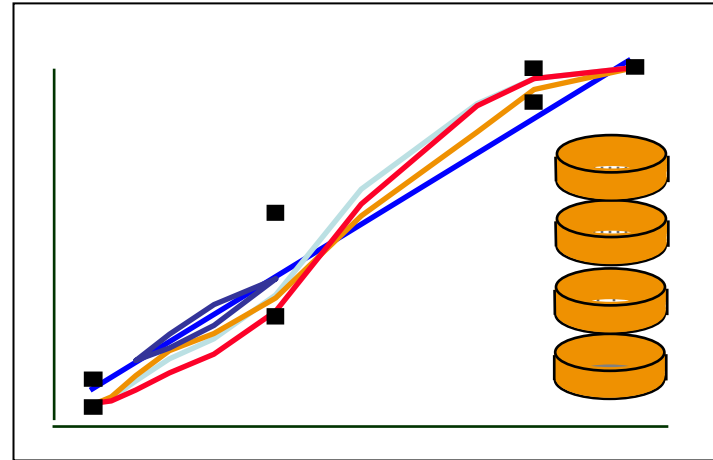
Ram pressure
600 kPa



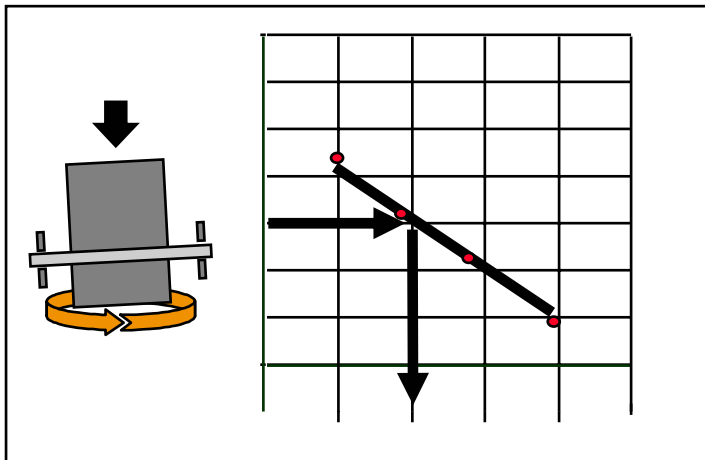
The Superpave System



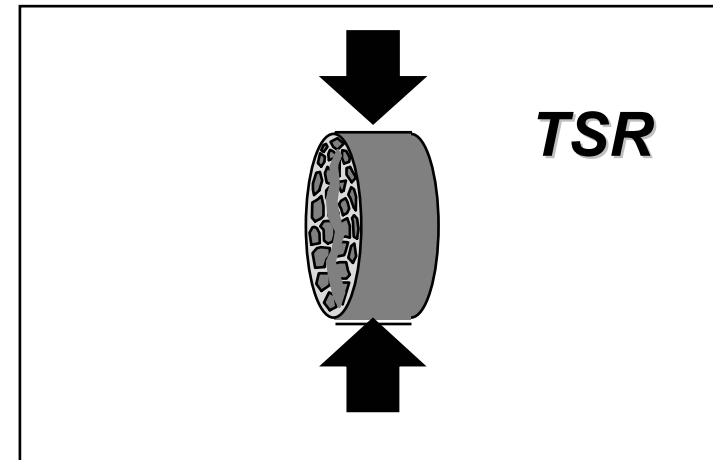
1. Materials Selection



2. Design Aggregate Structure

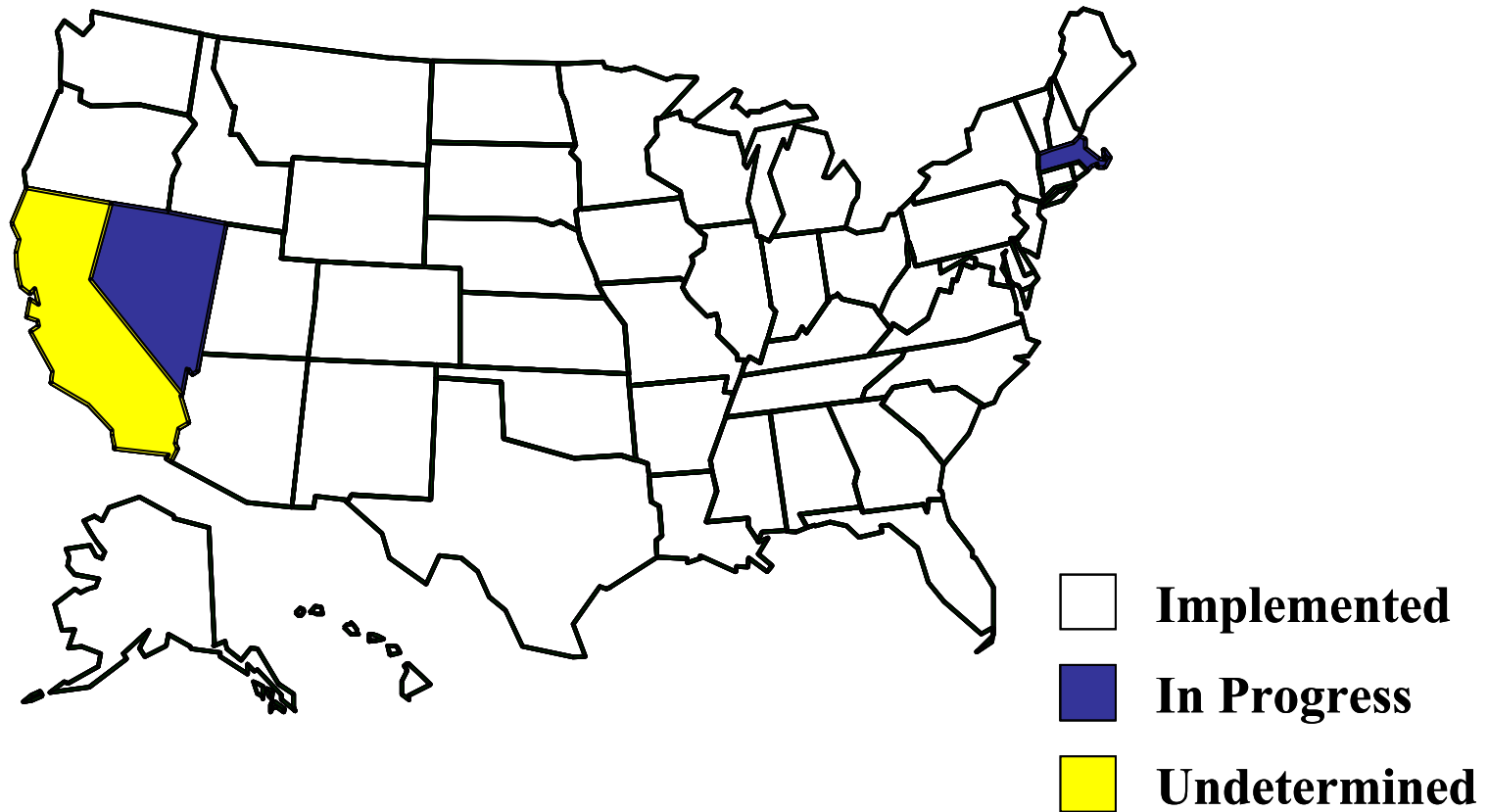


3. Design Binder Content



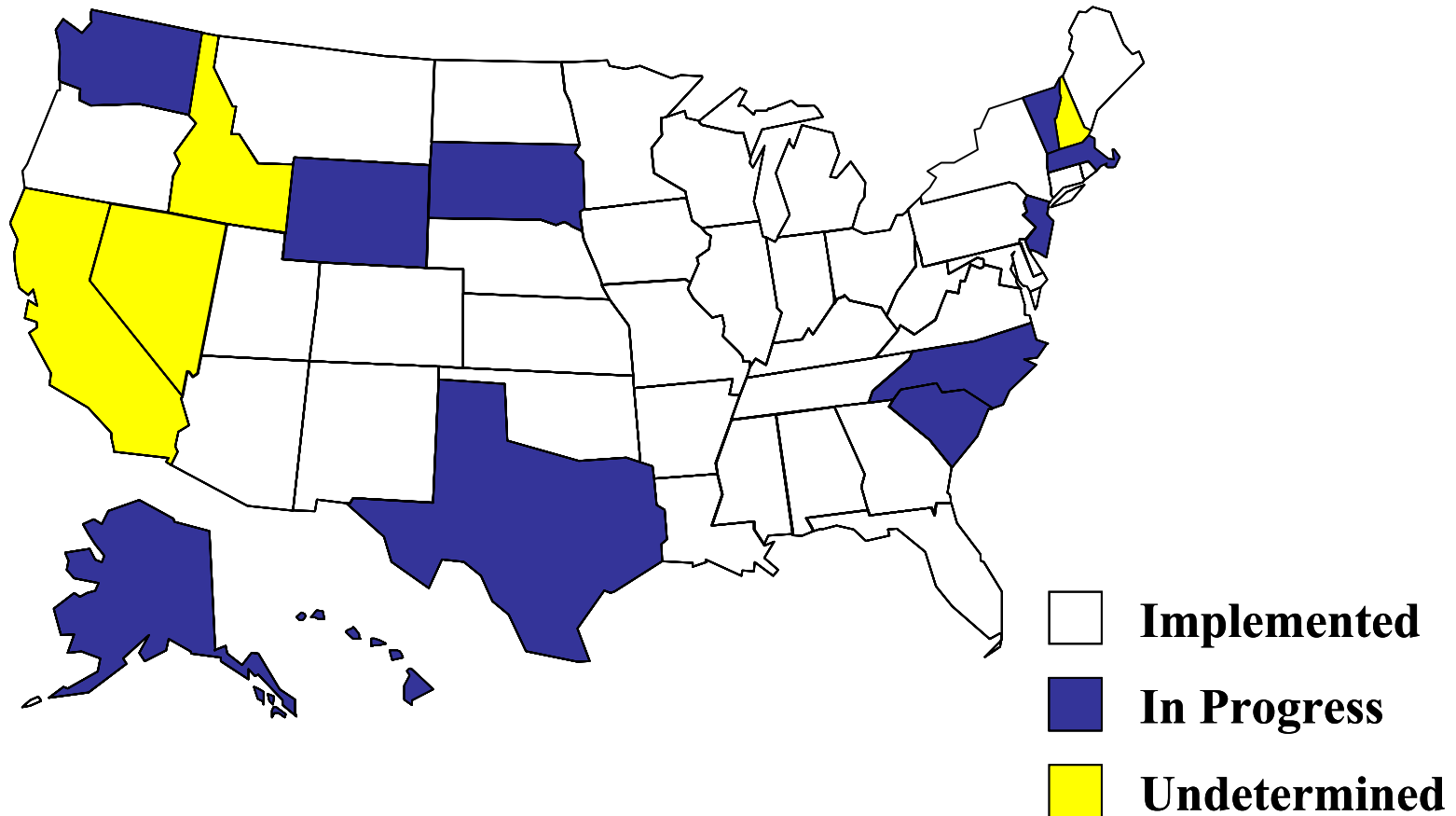
4. Moisture Sensitivity

Asphalt Binder Implementation Status

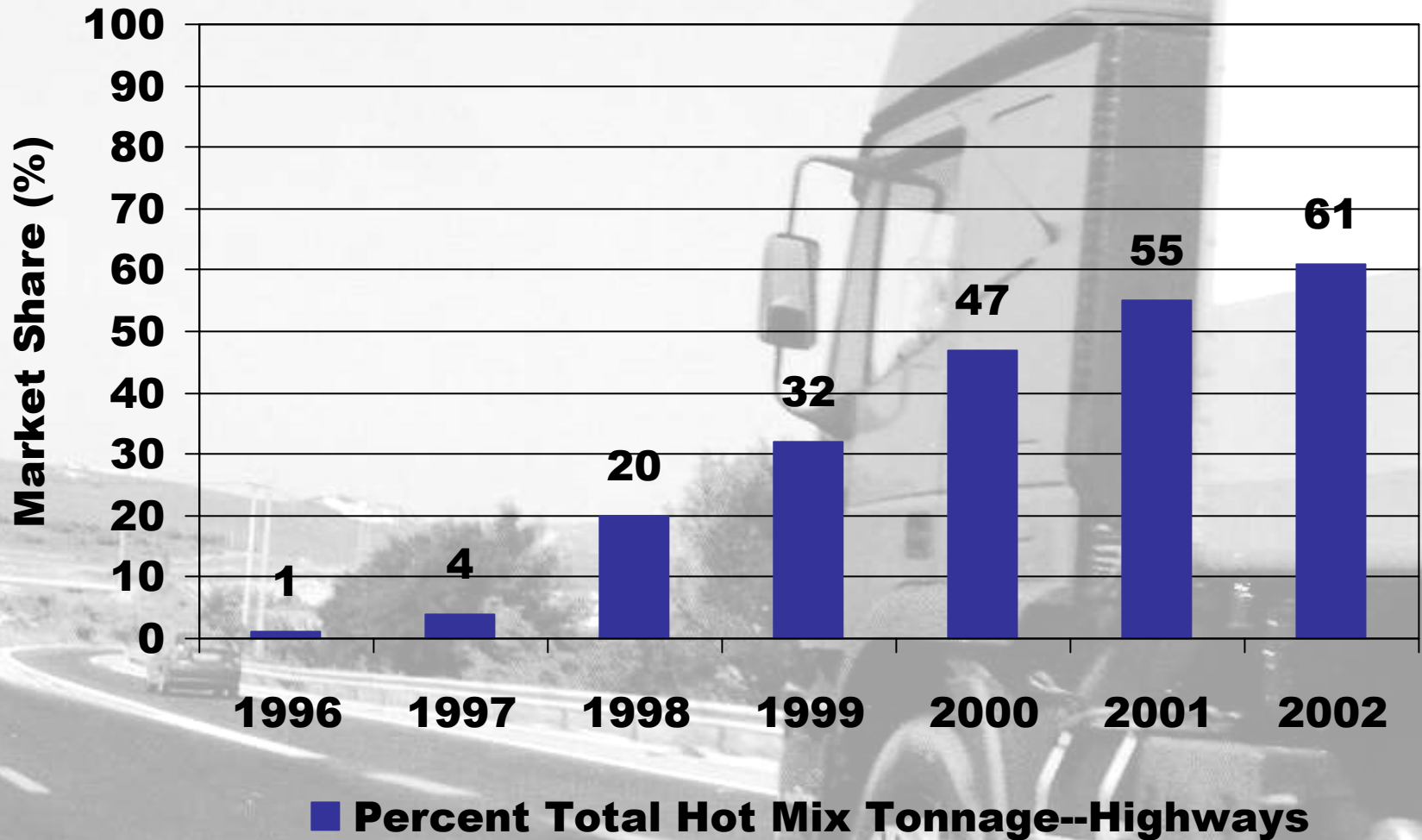


Superpave® 2002

Mix Design Implementation Status



US Superpave Market--Highways





Total U.S. Civilian Airports: 18,345

90% of Runway Surfaces Are Asphalt



Benefits of Superpave

- State-of-the-Art in Mix Design
 - Widely accepted by state highway agencies
- Superpave Gyratory Compactor
 - More representative of compaction in field
- Improved Material Requirements
 - Performance Graded Binders
 - Improved Aggregate Characteristics



HMA Airfield Paving Specifications

Federal Airfield HMA Specs.

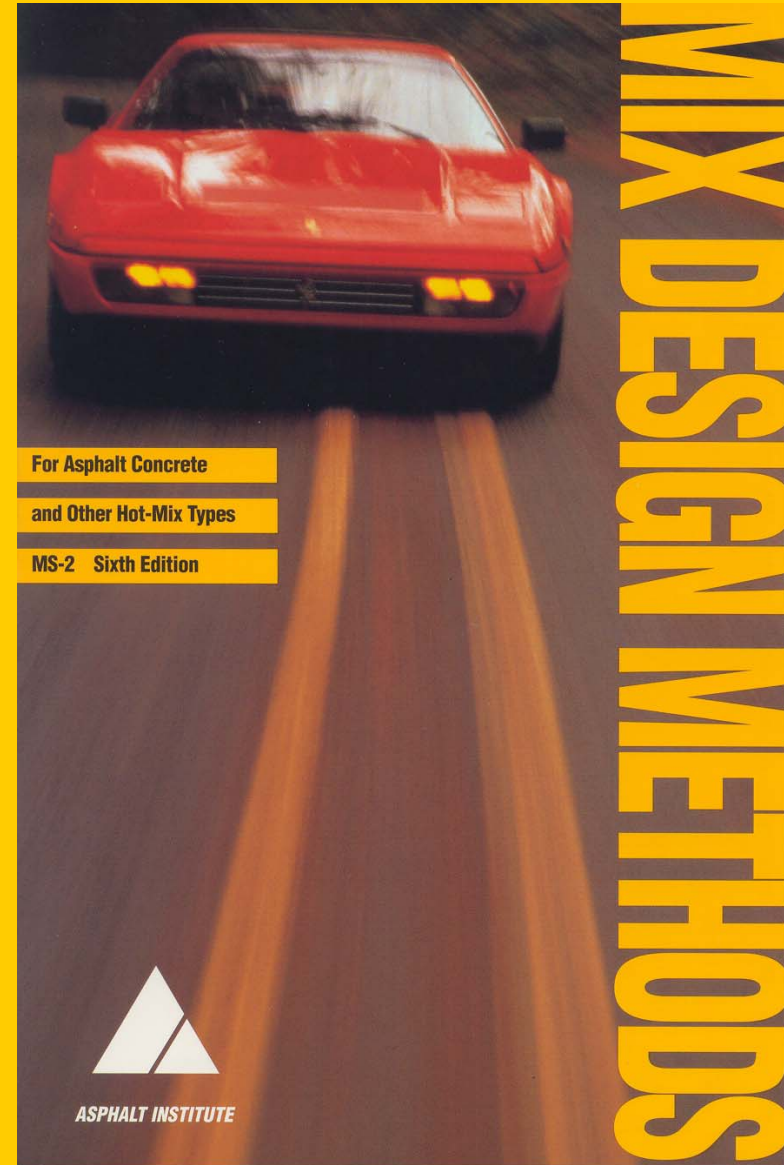
- Federal Aviation Administration
 - Item P-401, *Plant Mix Bituminous Pavements*
 - www.faa.gov/arp
 - P-401(Superpave)
 - **Engineering Brief 59**
 - State Standards
 - **For General Aviation Airfields**
- Department of Defense
 - Unified Guide Spec 02749, *HMA for Airfields*
 - www.hnd.usace.army.mil/techinfo/gspec



Item P-401

- Marshall Method of Mix Design
- Asphalt Institute MS-2

For pavements subjected to aircraft over 12,500 lb



FAA Engineering Brief 59

EB 59, Dec 18, 2001, provides a Superpave guide specification, P-401(SP), for the following airport pavements:



All < 60,000 lbs

Taxiways, Aprons > 60,000 lbs



State Specs Allowed by FAA

**Allowed on any
Airport with
Design Aircraft
< 12.5K lbs**

**Need FAA
Regional Office
Approval for
Airports with
Design Aircraft
12.5K to 60K lbs**





DoD Spec 02479 Allowed by FAA

**Marshall Mix Design,
Agg Specs very
Similar to P-401 SP**

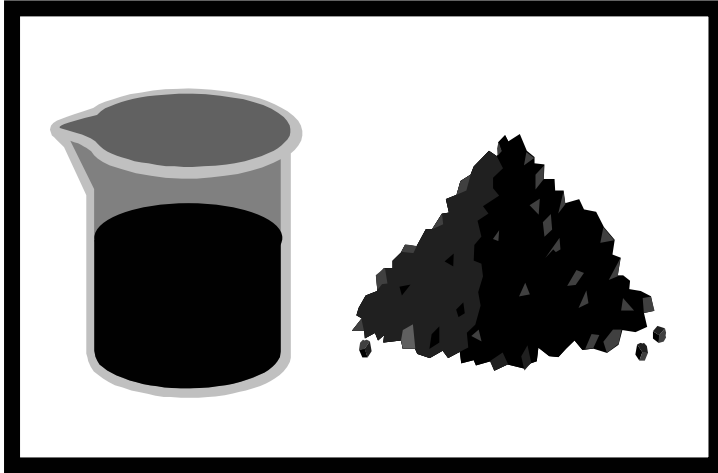
**Used by COE, USAF,
and Navy—Need
Regional Office
Approval for Use by
FAA**



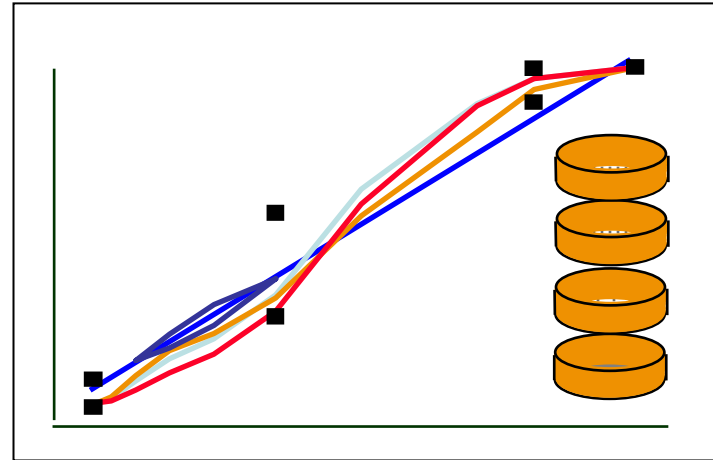


Superpave Overview

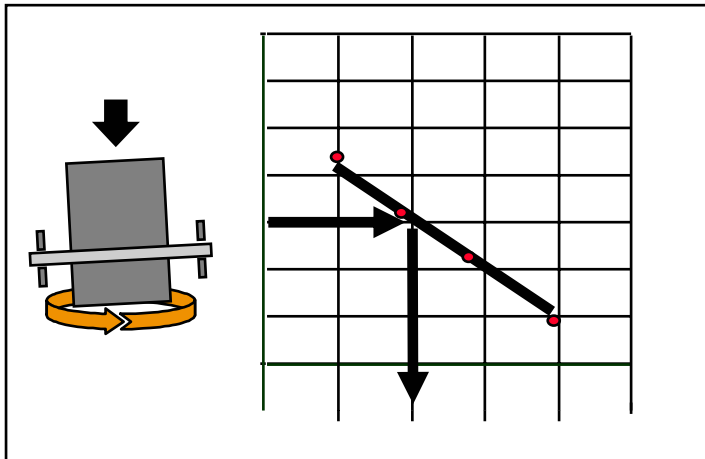
The Superpave System



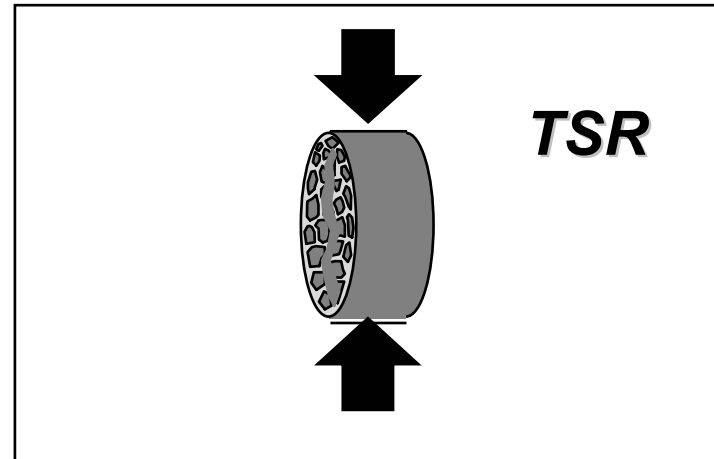
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2. Design Aggregate Structure



3. Design Binder Content

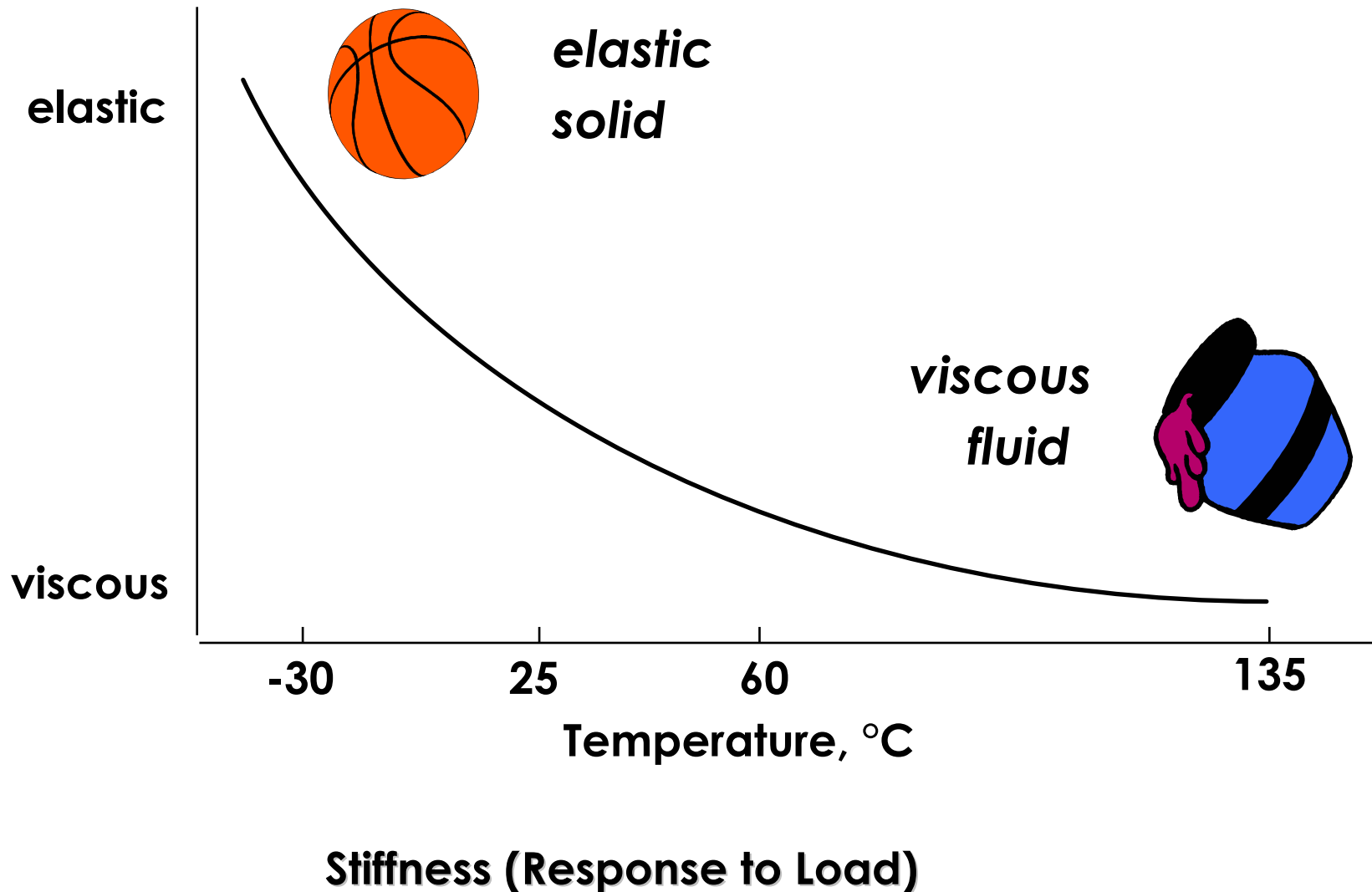


4. Moisture Sensitivity

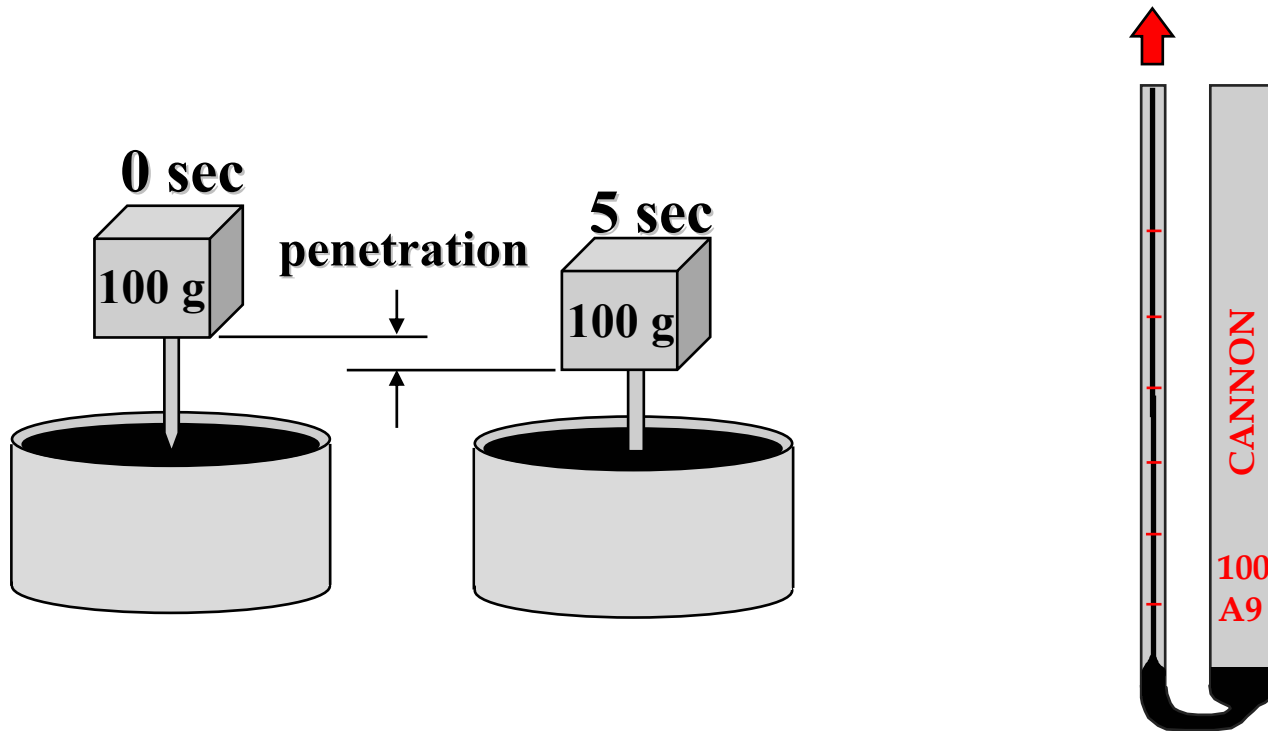


Superpave PG Binders for Airfields

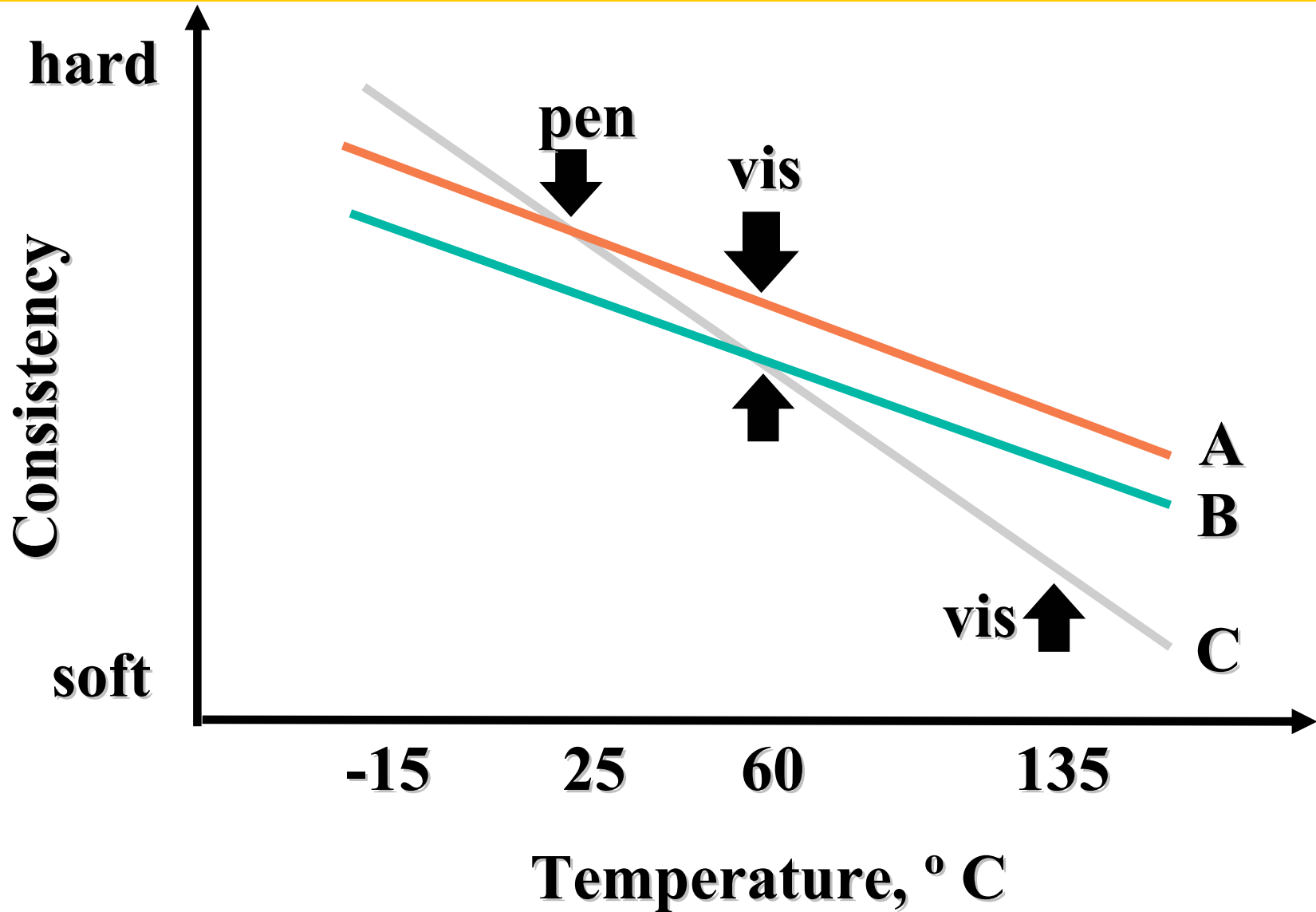
Asphalt Stiffness Varies w/ Temp



Penetration and Viscosity



Shortcomings of Old AC Specs



Superpave Asphalt Binder Specification

Grading System Based on Climate

PG 64-28

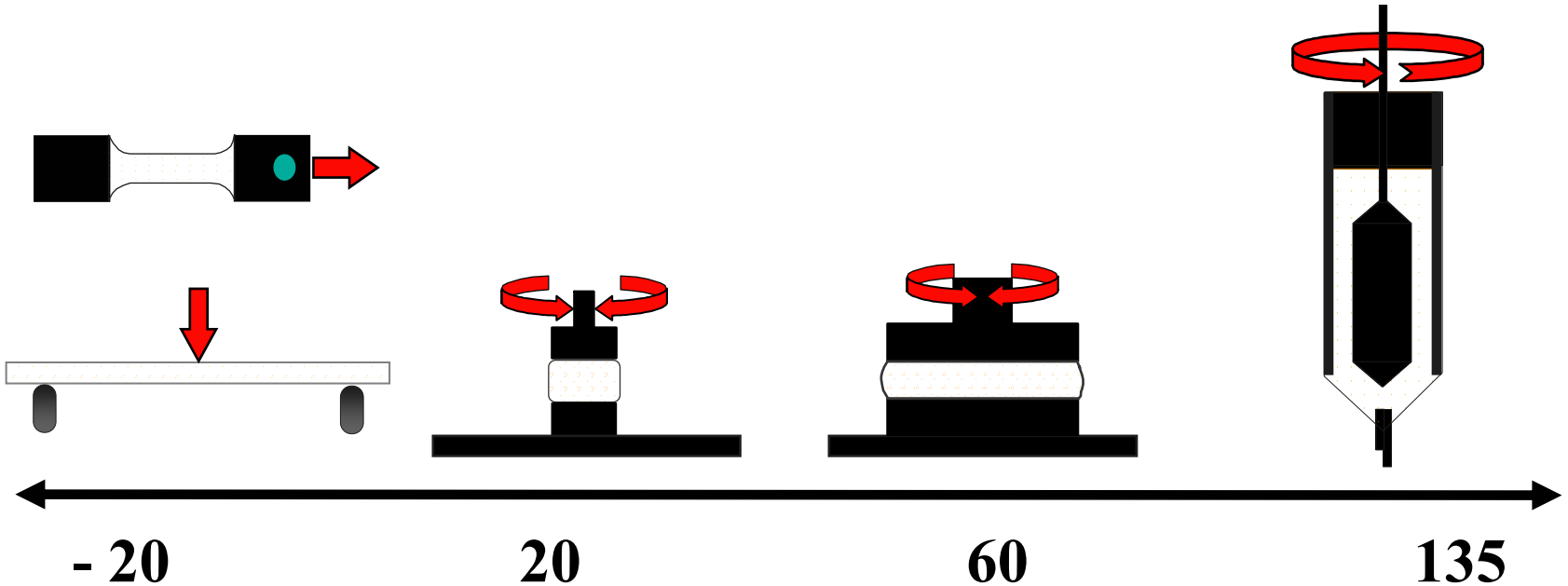
Performance
Grade

Average 7-day
max pavement
design temp

Min pavement
design temp



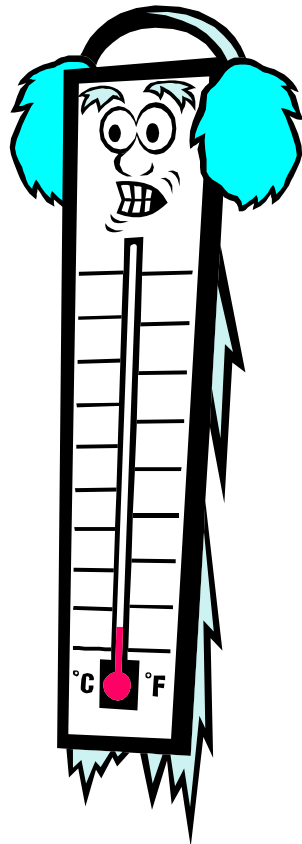
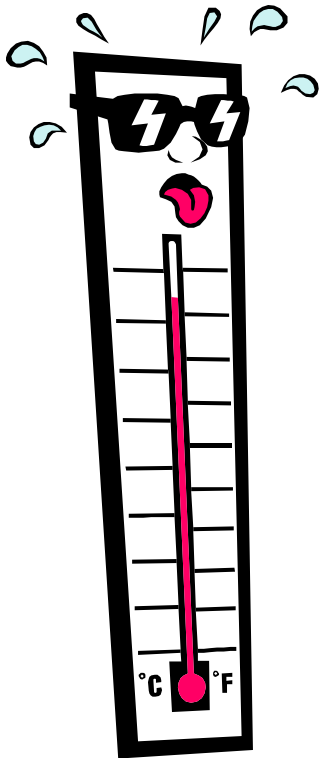
Superpave PG Binder Tests



Pavement Temperature, °C

Asphalt Binder Grade

Function of climate, load, and pavement application (runway, taxiway, or apron)



FAA Guidelines

Aircraft Gross Weight (lbs)	High Temperature Grade Adjustment(s) for Binders	
	Pavement Type	
	Runways	Taxiways and Aprons
< 12,500	-	-
< 60,000	-	1
< 100,000	N/A	1
> 100,000	N/A	2

FAA P-401 Superpave Specification Table A

FAA and DoD General Guidelines

➤ Consult with local DOT

- Determine PG grades typically used and available
- Determine “Standard Grade” for Specific Location
 - typically used for highways with <10M ESALs
 - sufficient on most GA airports
- Consider “Bumping” from “Standard Grade” (top 5” only) if concerned with rutting
 - past performance?
 - tire pressures?
 - standing or slow traffic?



Effect of Load & Loading Rate

- For $< 12.5K$ PG 64-22
- For $< 60K$ PG 70-22
- For $< 100K$ T/W & Apron PG 70-22
- For $> 100K$ T/W & Apron PG 76-22

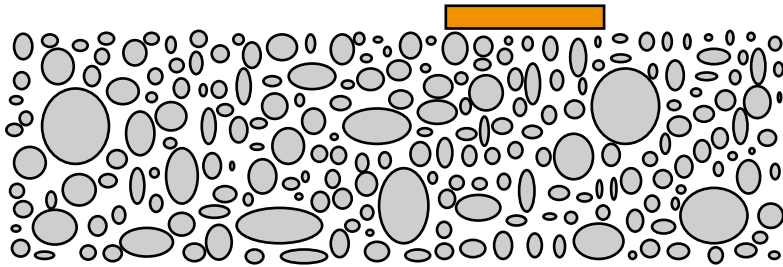




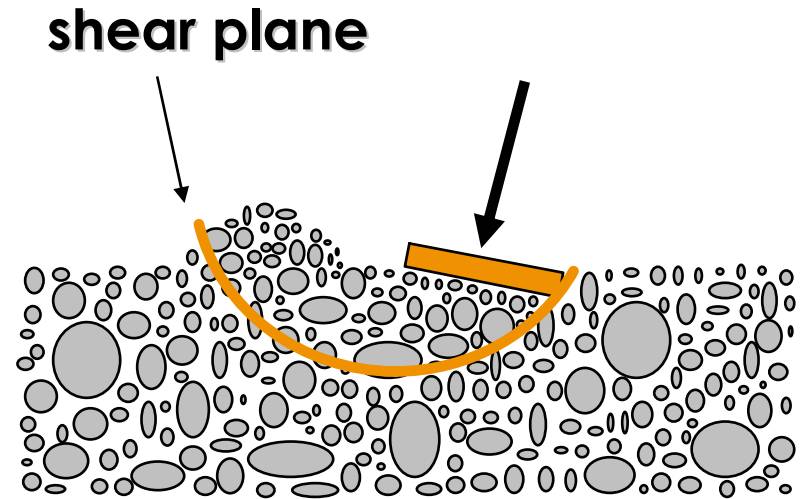
Superpave Aggregate Quality



Shearing Behavior of Aggregate



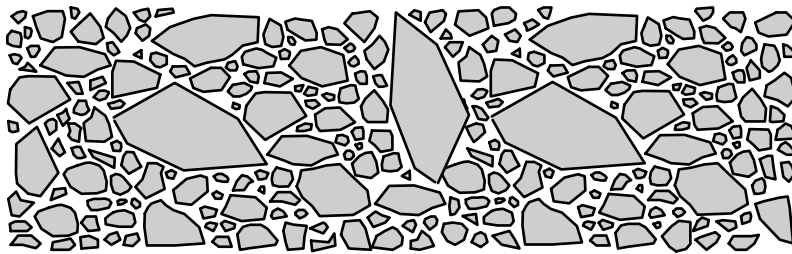
Before Load



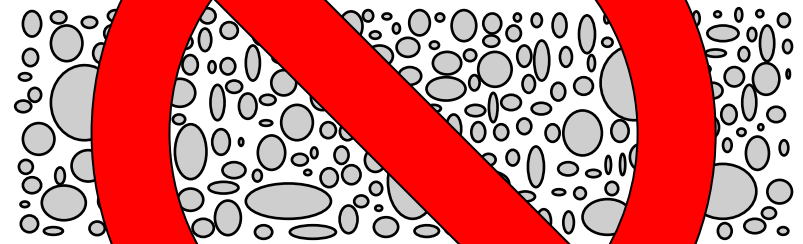
After Load

Contrasting Stone Skeletons

Increase Percentage of Crushed Faces
Increase Percentage of Crushed Faces



Cubical Aggregate



Rounded Aggregate

Limit Amount of Natural Sand
Limit Amount of Natural Sand

Superpave Aggregates



Superpave Aggregates



Material Quality—Coarse Agg

Measurement	P-401 Marshall	P-401 Superpave
LA Abrasion	$\leq 40 \%$	$\leq 40 \%$
Sodium Sulfate	$\leq 10 \%$	$\leq 10 \%$
Magnesium Sulfate	$\leq 13 \%$	$\leq 13 \%$
Fractured Faces (> 60K)	85/1 70/2	85/1 80/2
Fractured Faces (< 60K)	65/1 50/2	
Flat & Elongated	$\leq 8 \%$	$\leq 8 \%$ (5:1)

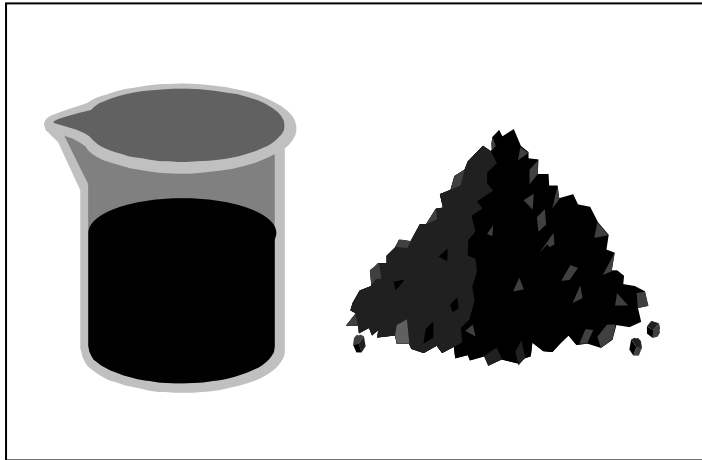
Specification Requires Improved Aggregate Quality

Material Quality—Fine Agg

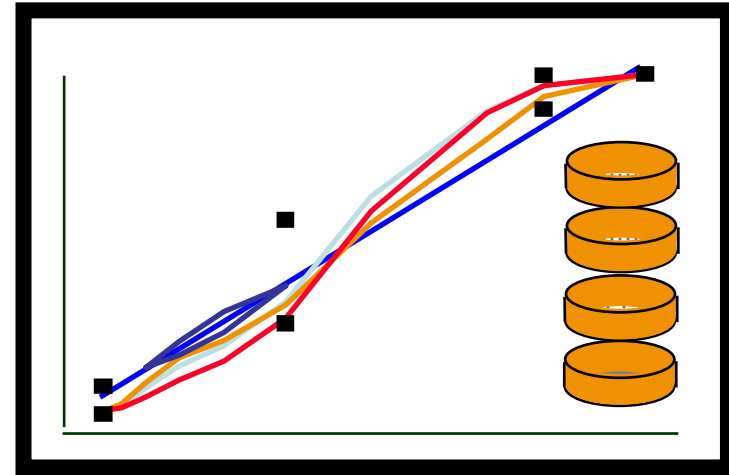
Measurement	P-401 Marshall	P-401 Superpave
Plasticity Index	$\leq 6 \%$	$\leq 6 \%$
Liquid Limit	$\leq 25 \%$	$\leq 25 \%$
Natural Sand	$\leq 20 \%$	$\leq 15 \%$
Sand Equivalent	$\geq 40 \%$	$\geq 40 \%$
Fine Aggregate Angularity	N/A	$\geq 45\%$

Specification Requires Improved Aggregate Quality

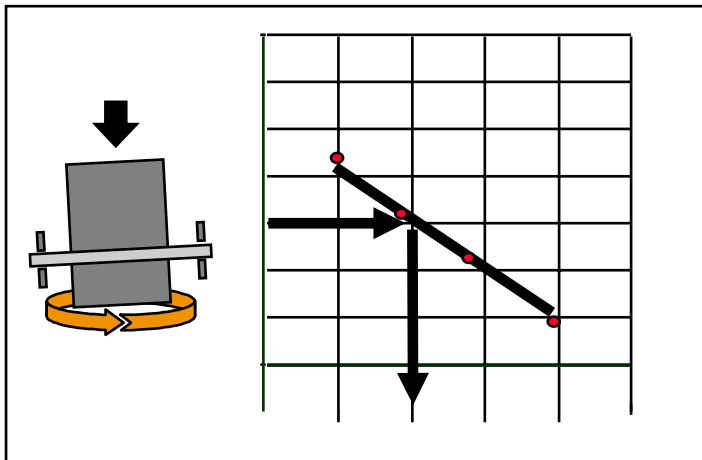
The Superpave System



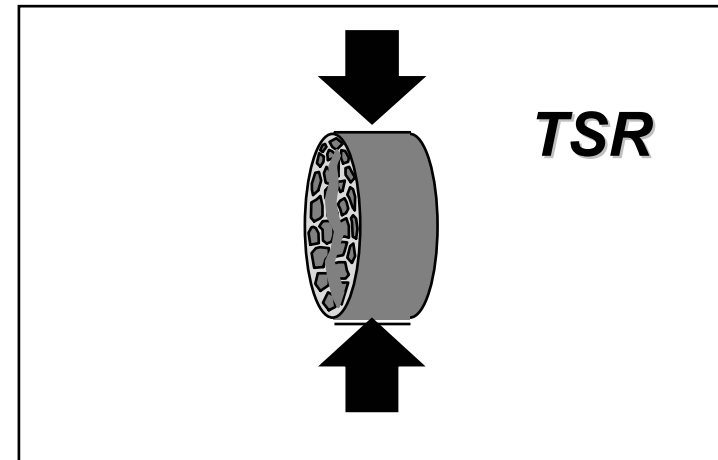
1. Materials Selection



2. Design Aggregate Structure



3. Design Binder Content



4. Moisture Sensitivity

Aggregate Size Definitions

100

100

90

72

65

48

36

22

15

9

4

- Nominal Maximum Aggregate Size (NMAS)
 - one size larger than the first sieve to retain more than 10%
- Maximum Aggregate Size
 - one size larger than nominal maximum size

100

99

90

72

65

48

36

22

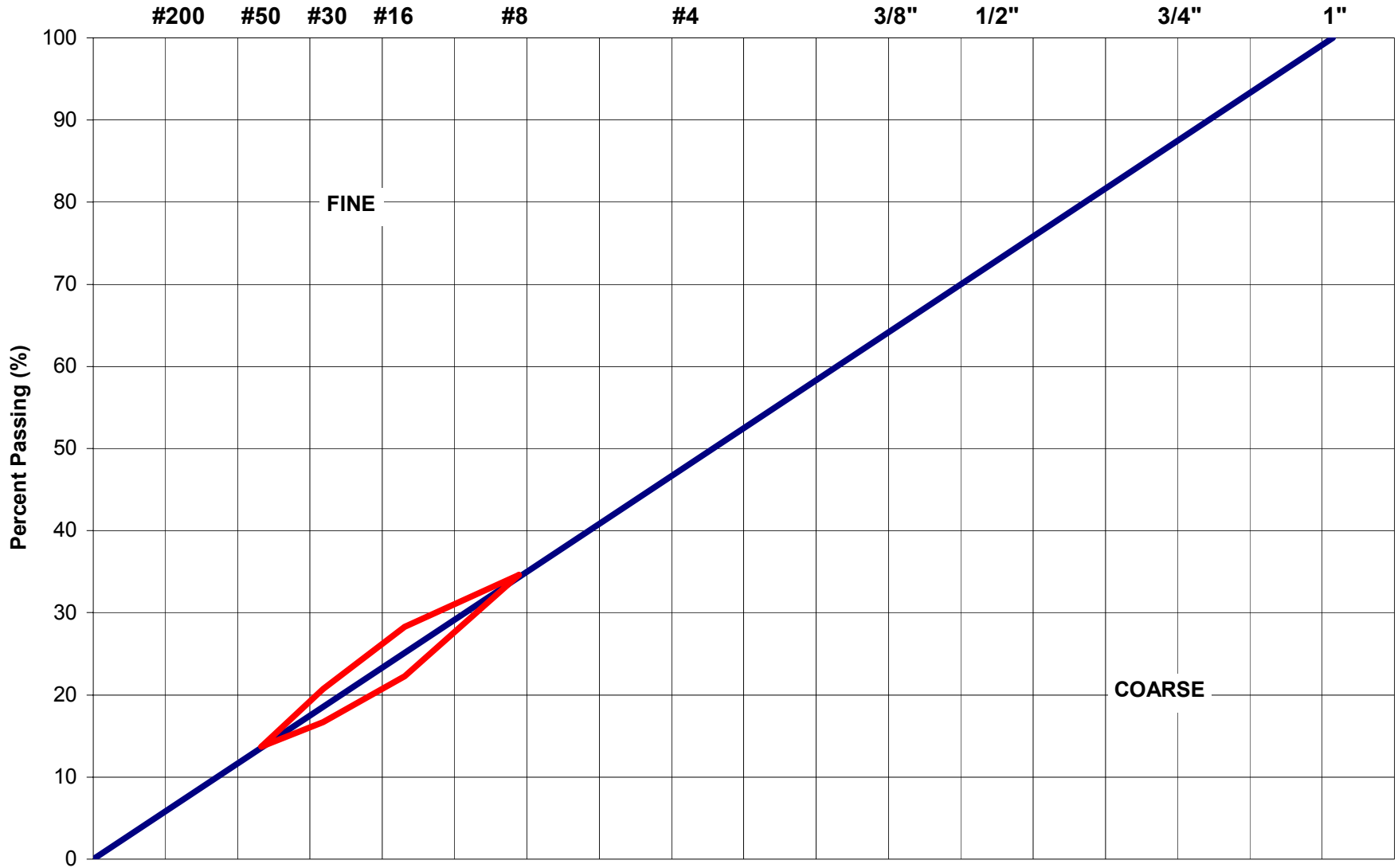
15

9

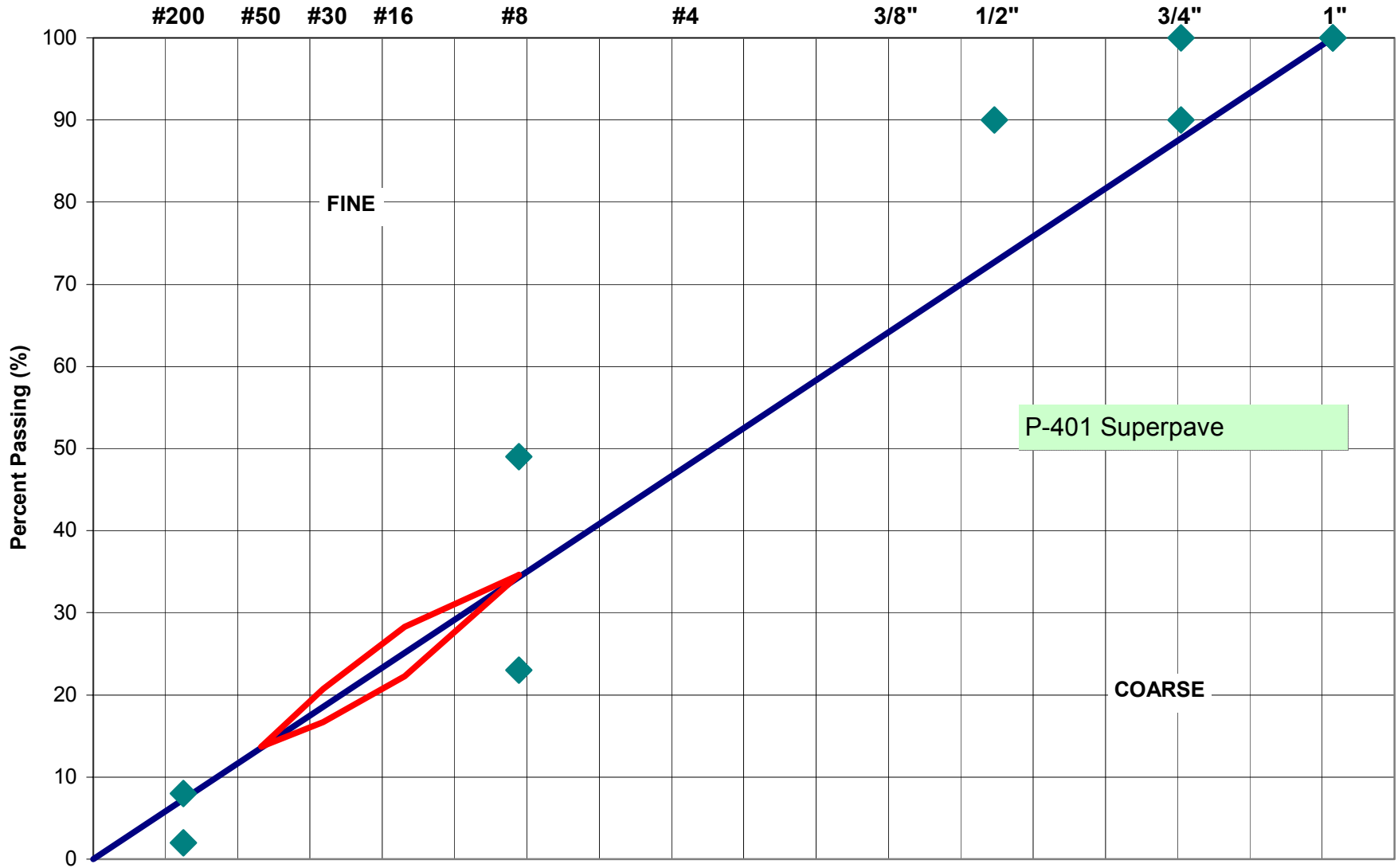
4



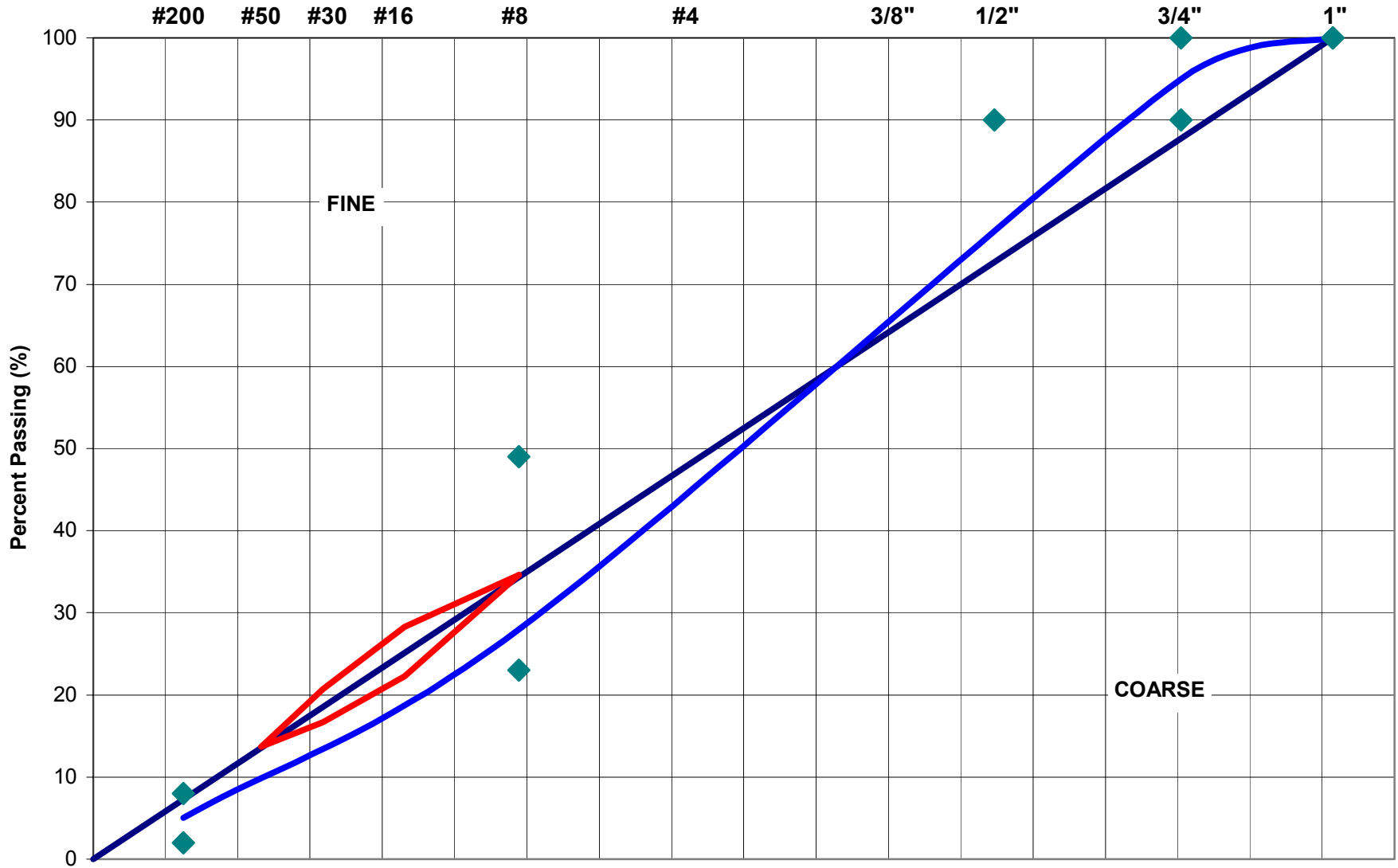
Superpave Gradation Analysis



Superpave Gradation Analysis



Typical Superpave Gradation



Superpave Aggregate Gradation

12.5 mm

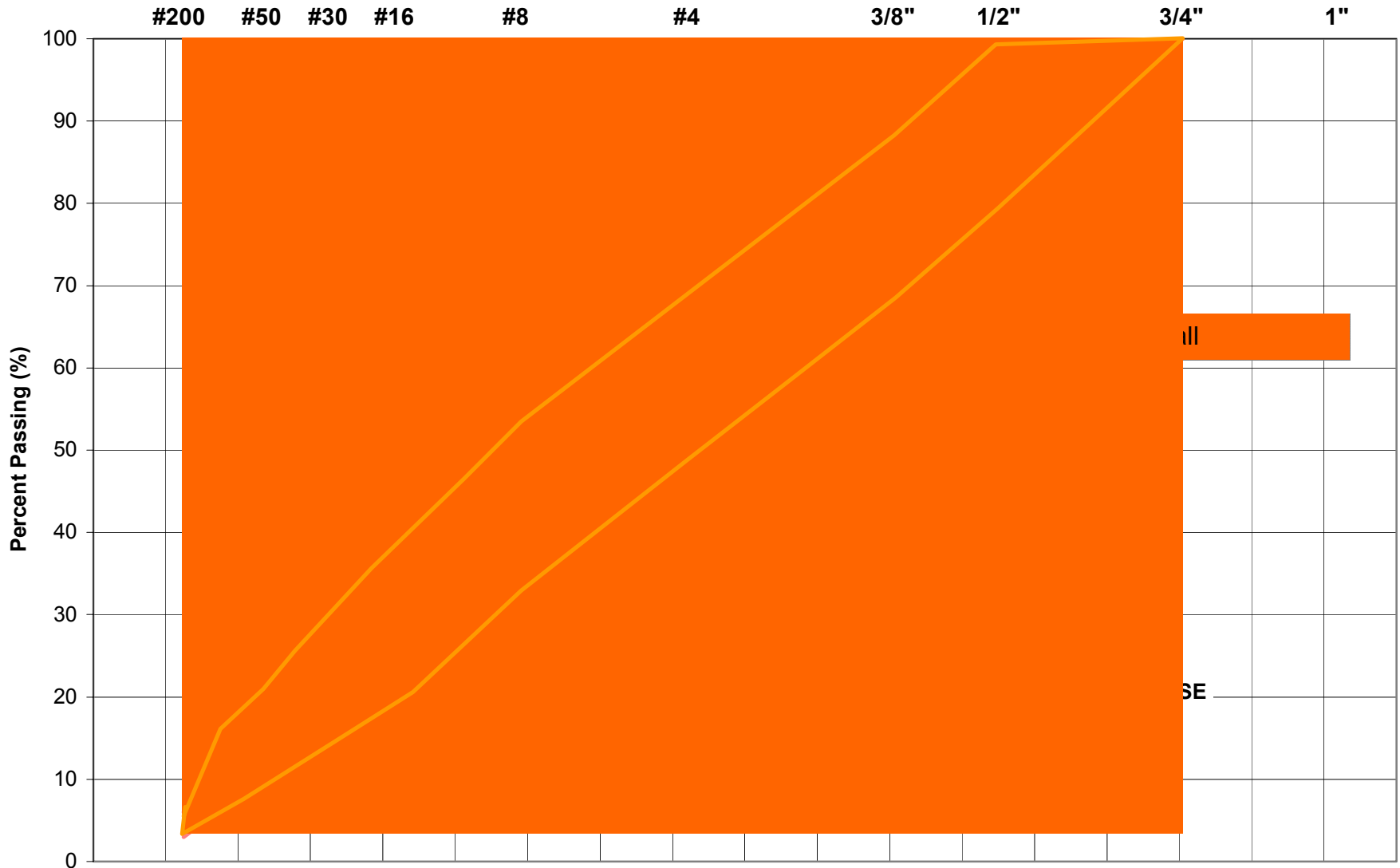


19.0 mm

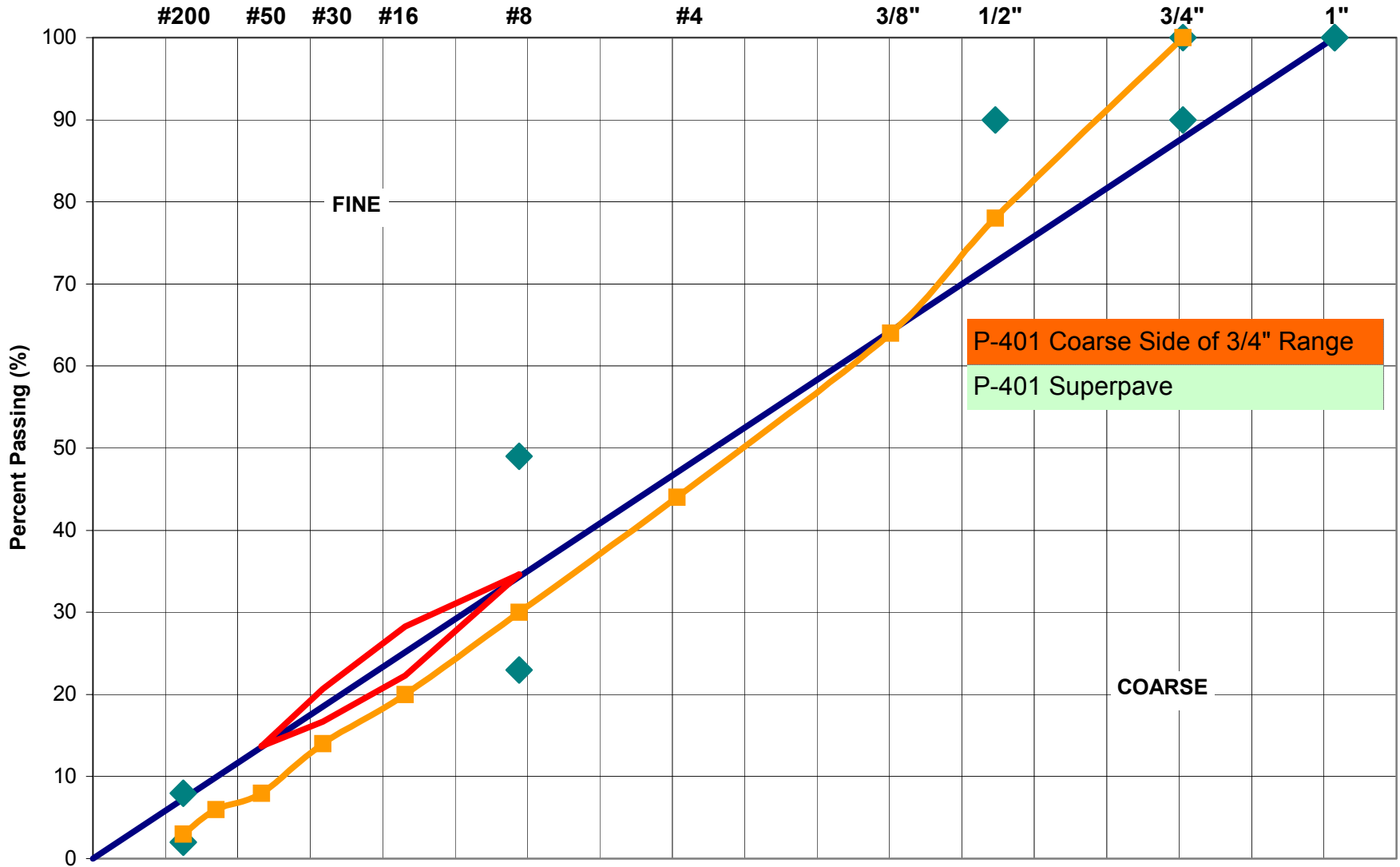




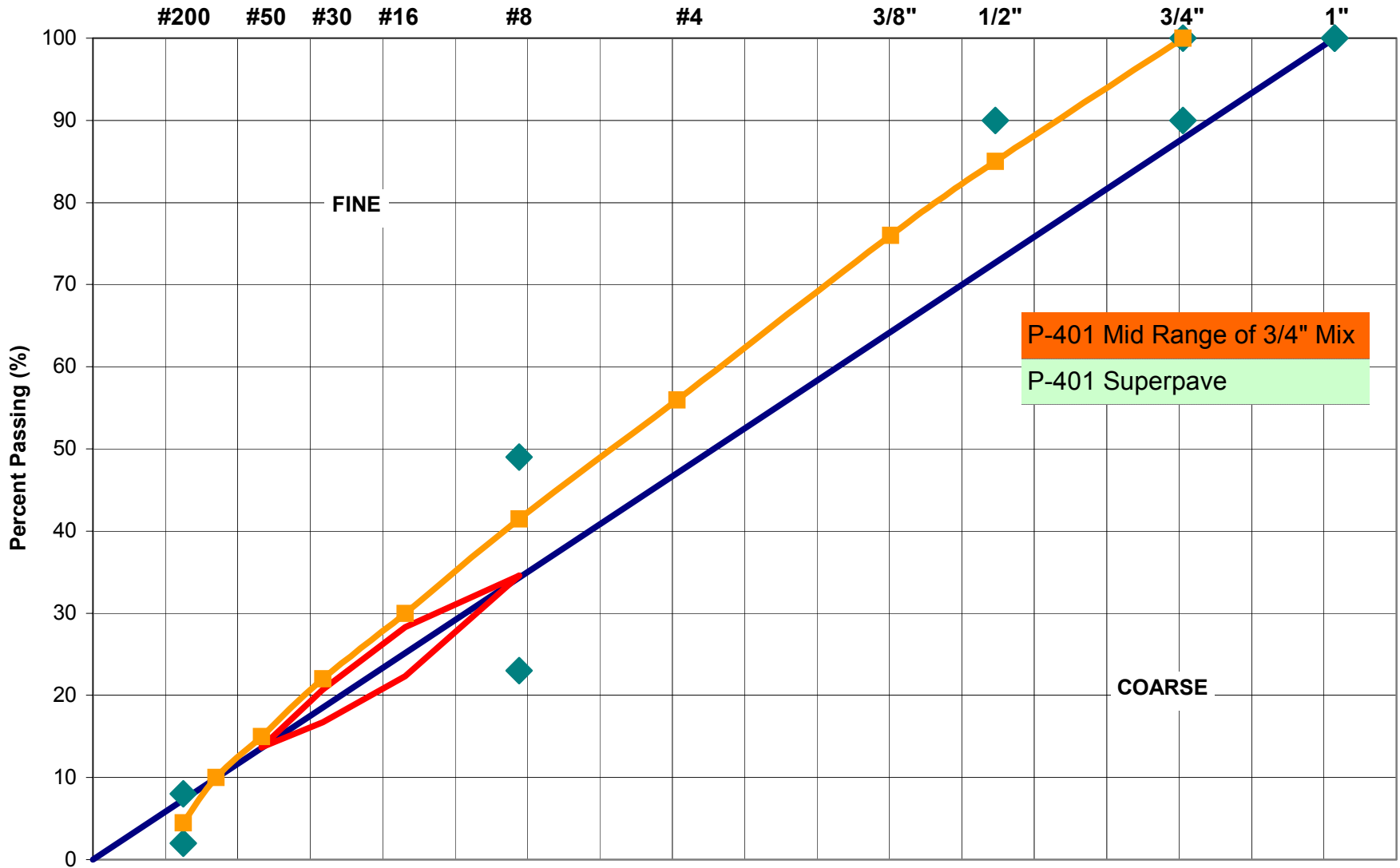
Typical FAA Gradation--3/4" Max



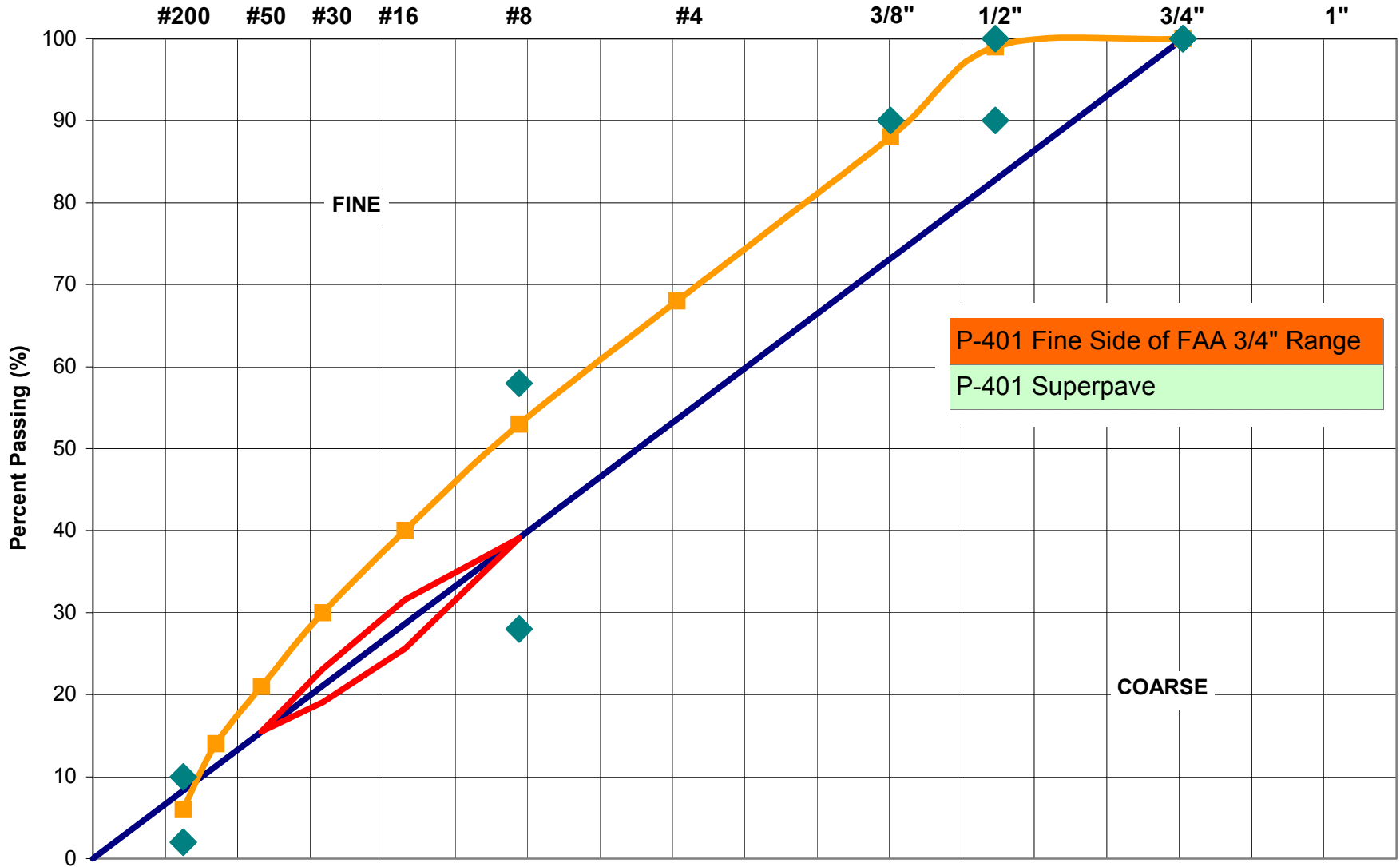
Typical FAA Gradation--3/4" Max



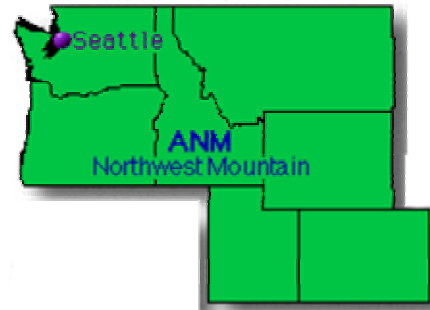
Typical FAA Gradation--3/4" Max



Typical FAA Gradation--3/4" Max



Coarser Aggregate Gradations

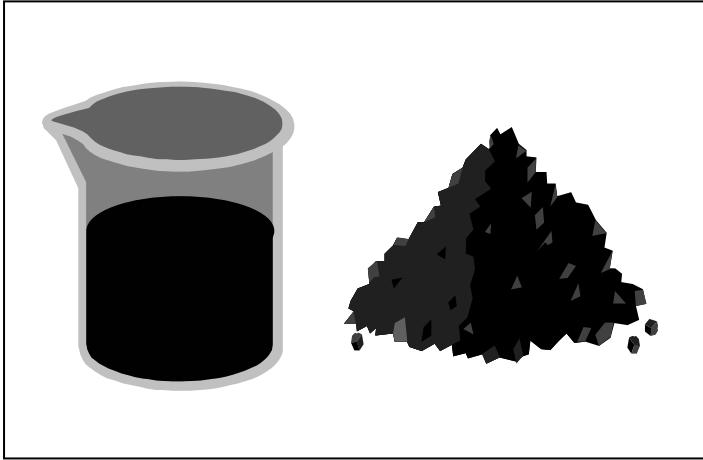


“The region has had a long history of success with coarser gradations that reduce the percentage of fine materials.”

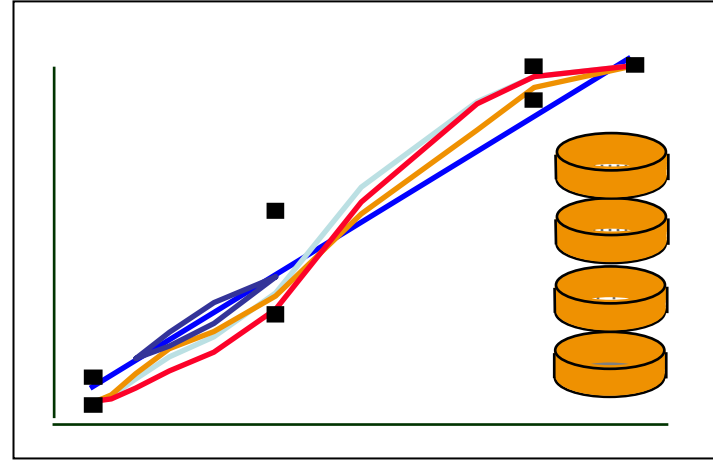
--FAA NW Mountain Region

Notice 14, January 2002

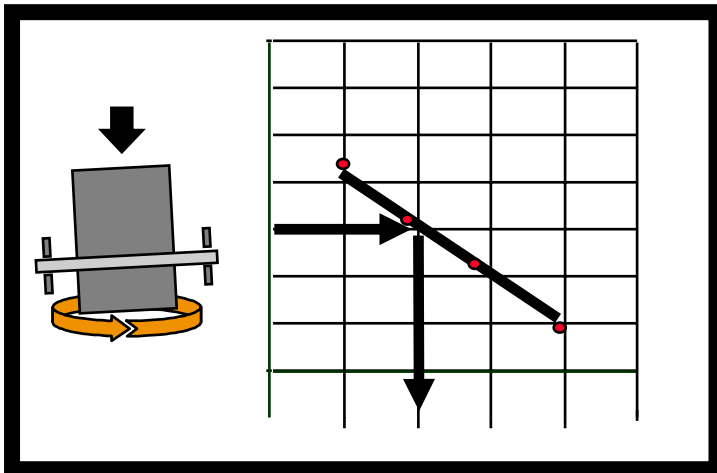
The Superpave System



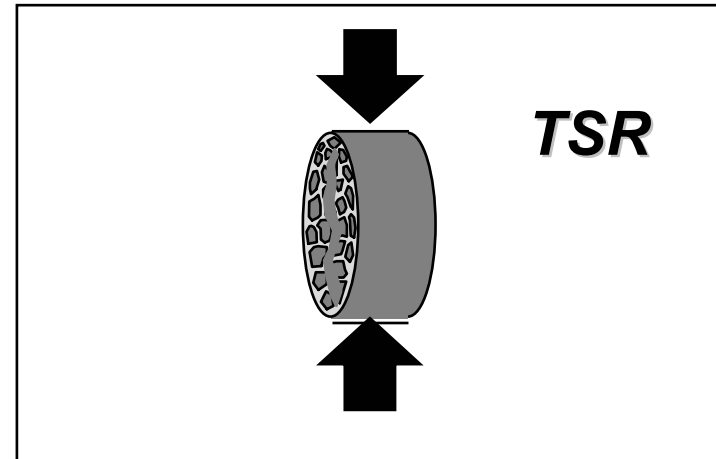
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2. Design Aggregate Structure

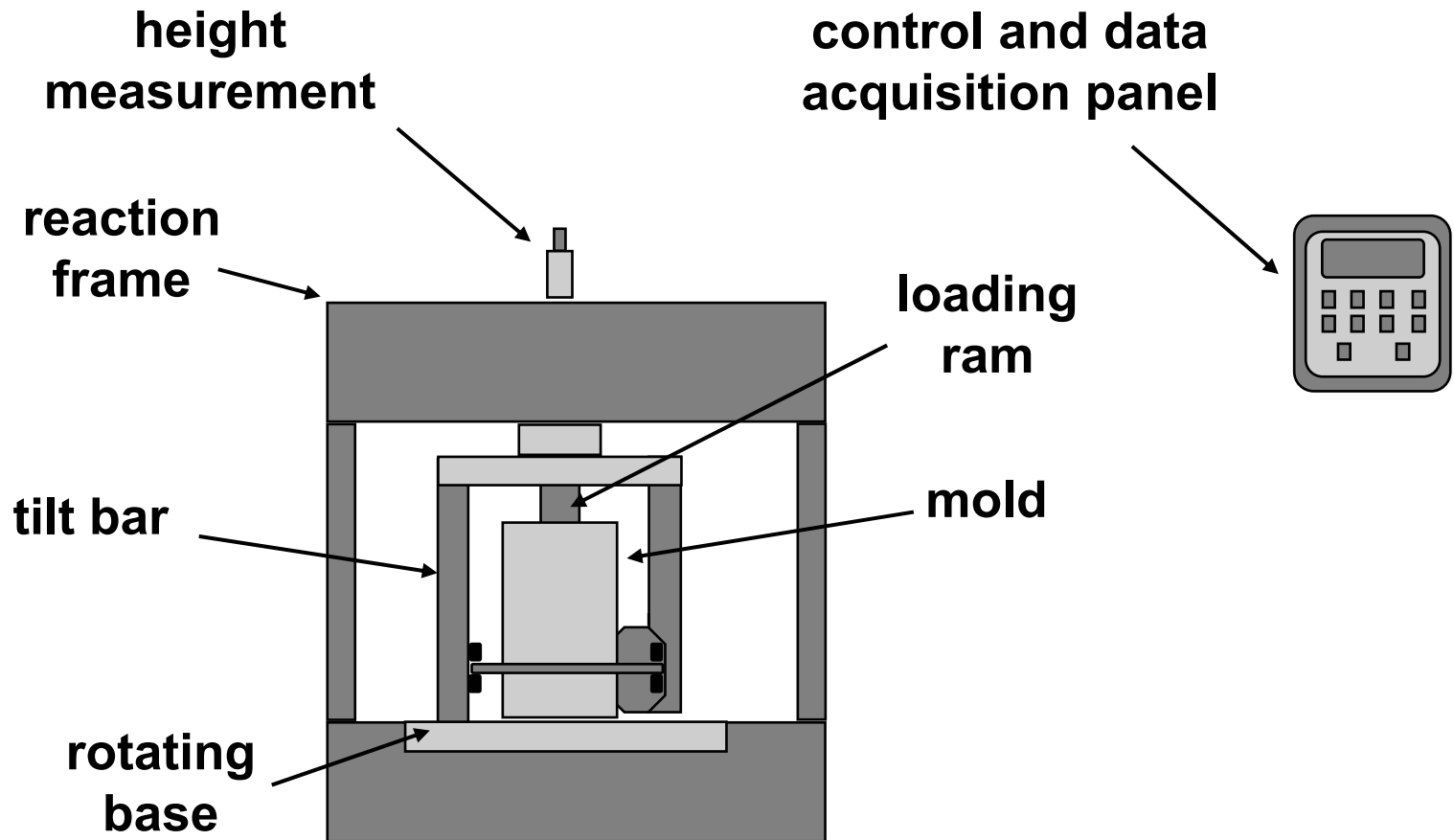


3. Design Binder Content



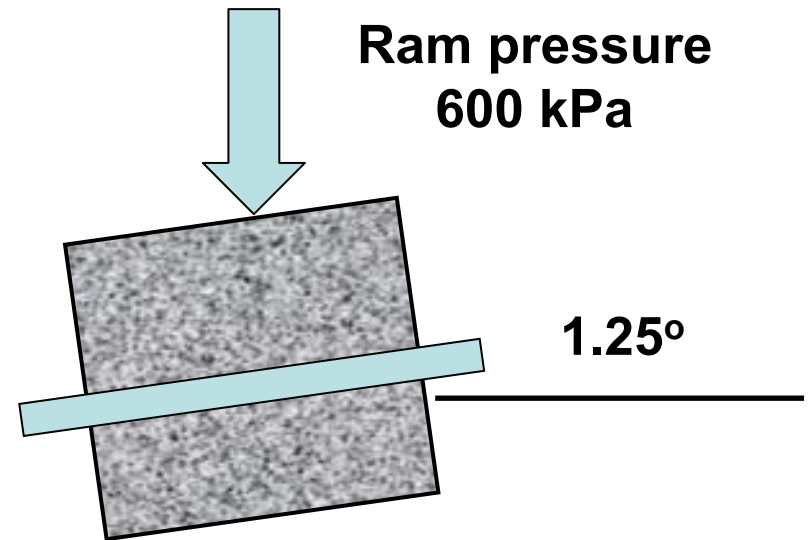
4. Moisture Sensitivity

Key Components of Gyrotory Compactor



Superpave Gyrotory Compactor

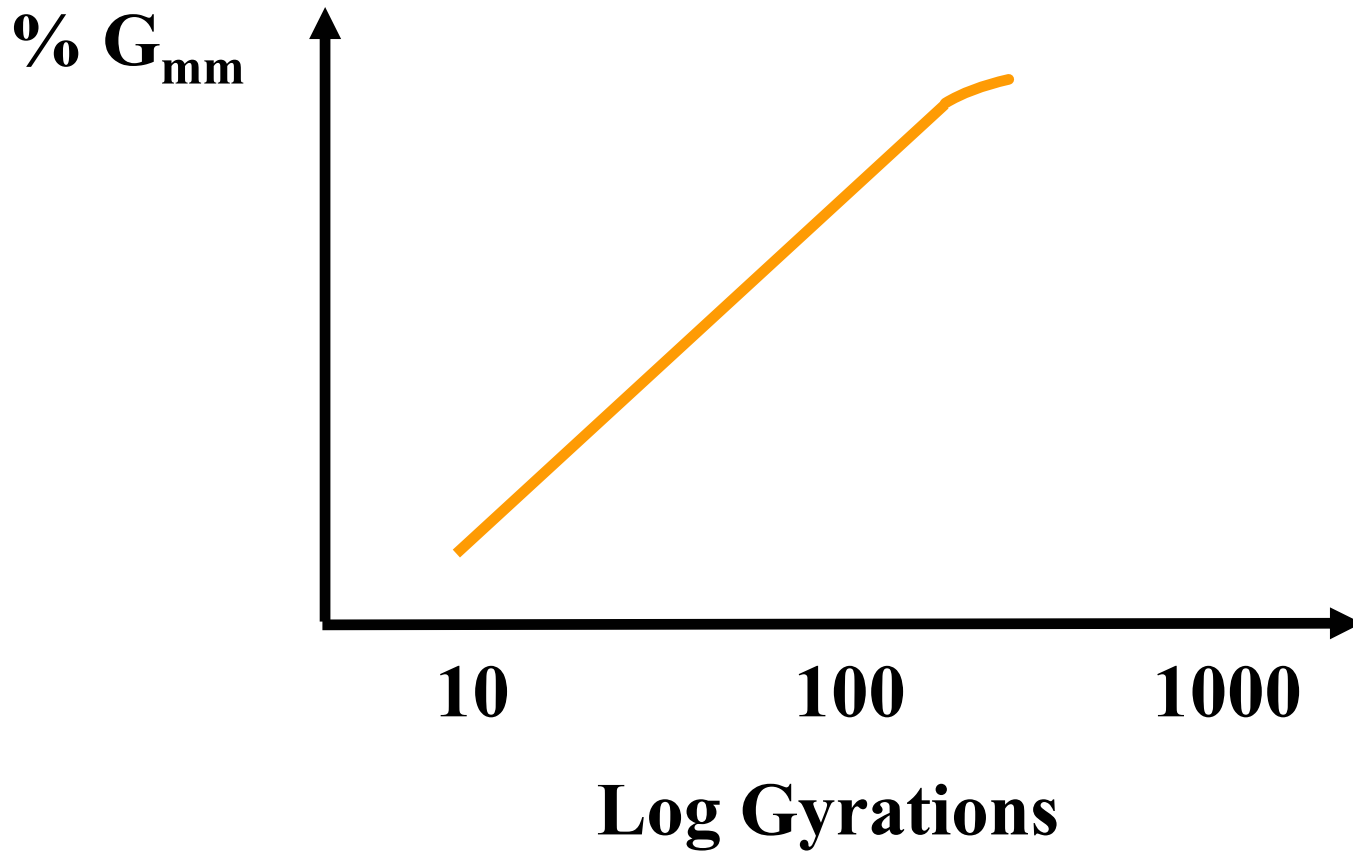
- Axial and shearing action
- 150 mm dia.molds
 - Aggregate size up to 37.5 mm
 - Height measurement during compaction allows densification to be evaluated



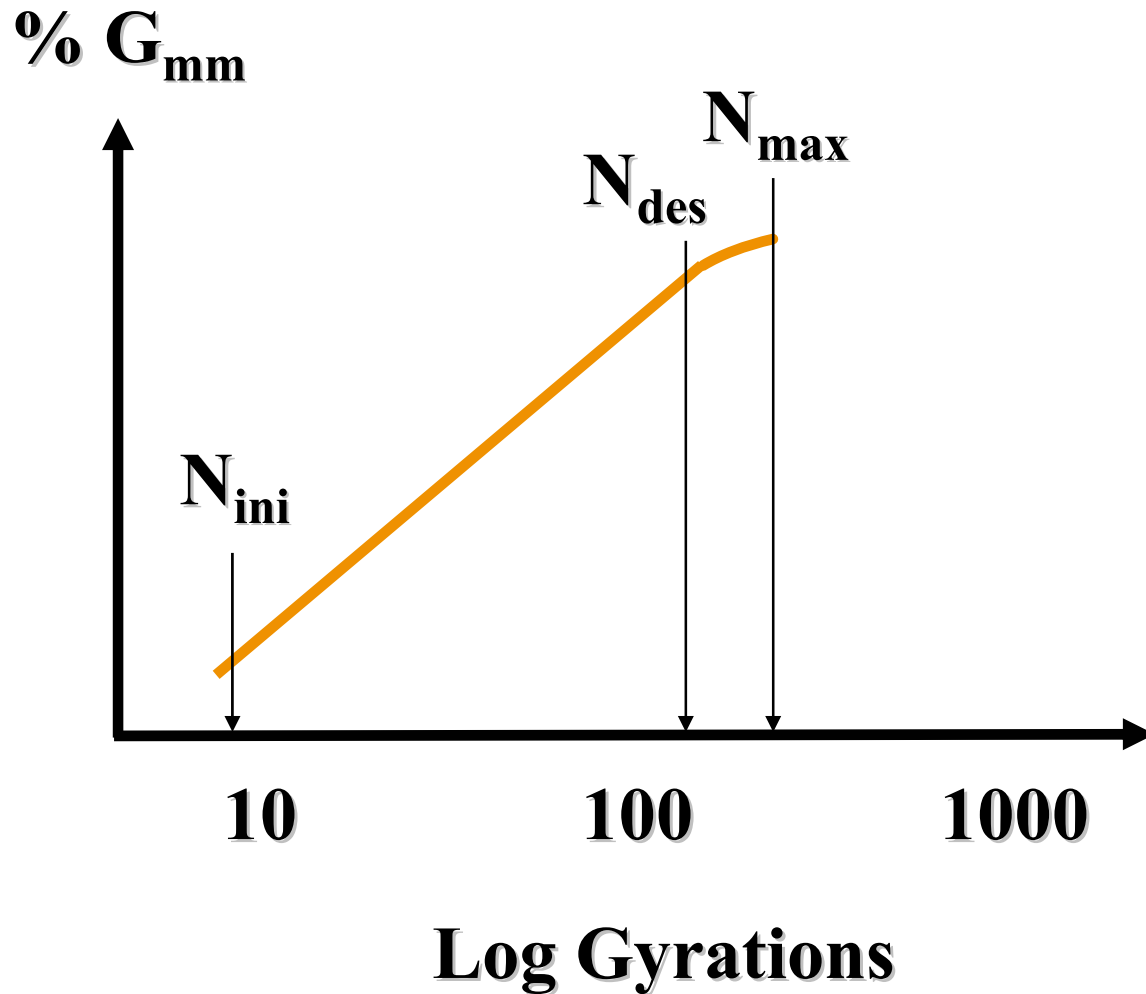
Superpave Gyrotory Compactors



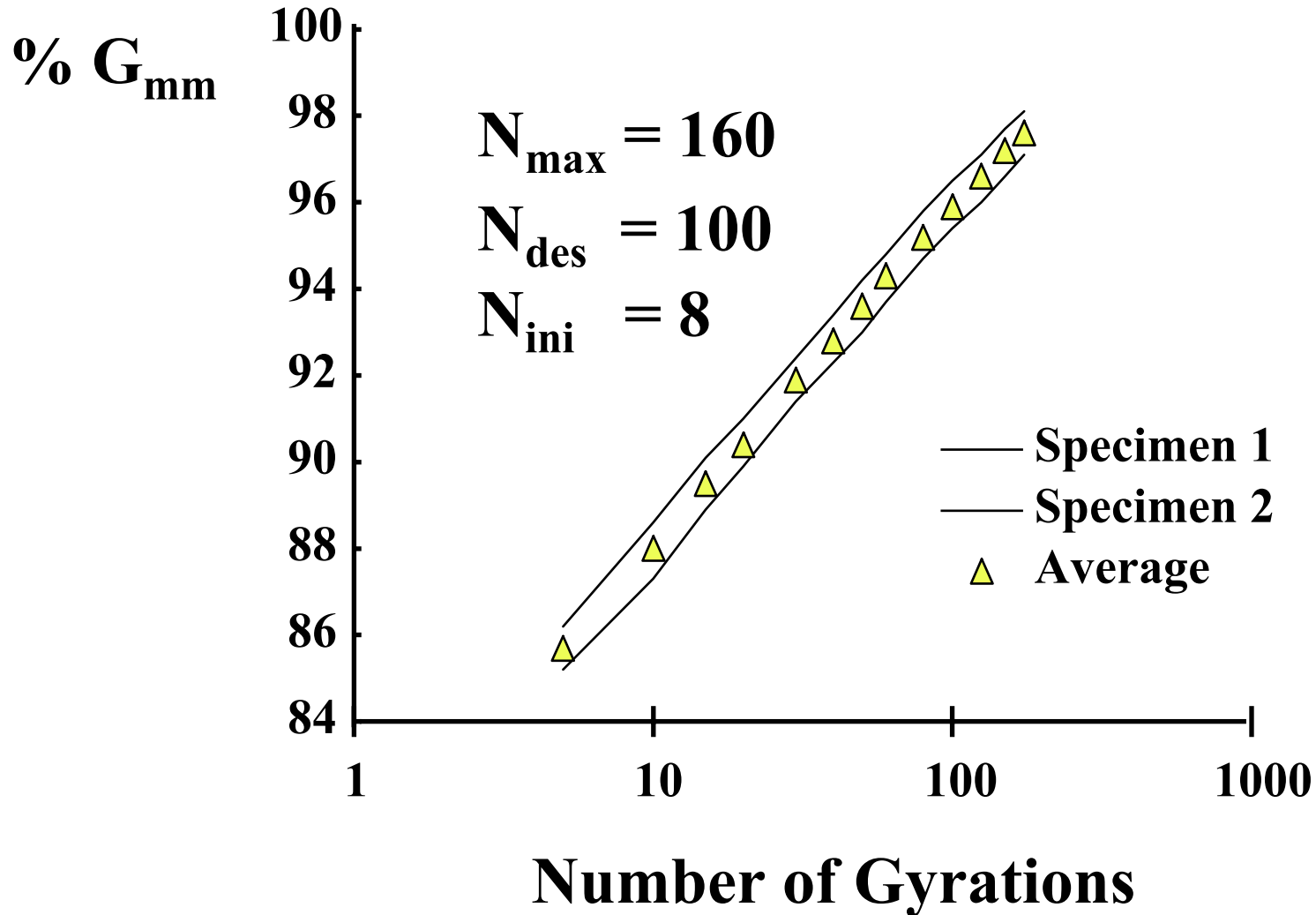
SGC Results



Three Points on SGC Curve



Data Presentation



Superpave Mix Design Requirements

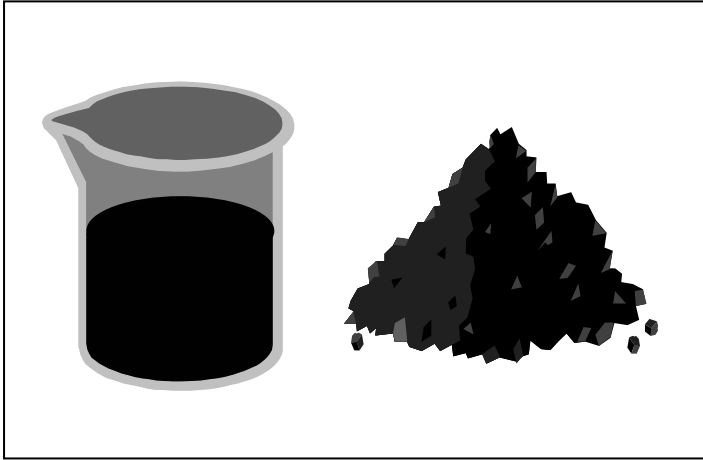
Determine mix properties at N_{Design} and compare to criteria

–Air voids	4% (or 96% G_{mm})
–VMA	See table
–VFA	See table
–% G_{mm} at N_{ini}	$\leq 89\%$
–% G_{mm} at N_{max}	$\leq 98\%$
–Dust proportion	0.6 to 1.2

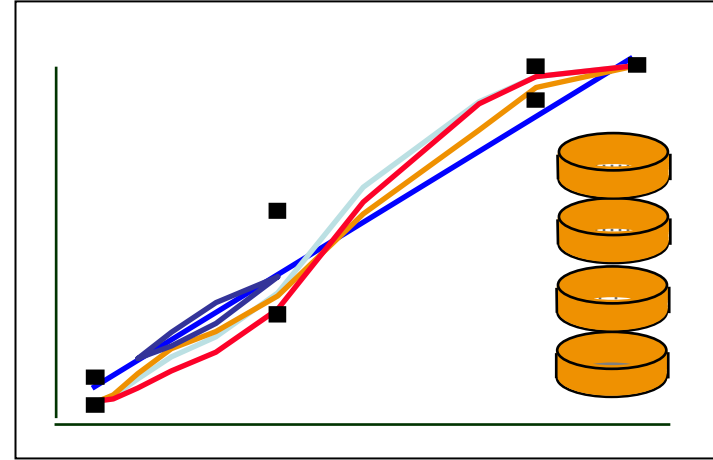
VMA Requirements

Nominal max agg size	Min. VMA
– 9.5 mm	15
– 12.5 mm	14
– 19 mm	13
– 35 mm	12
– 37.5 mm	11

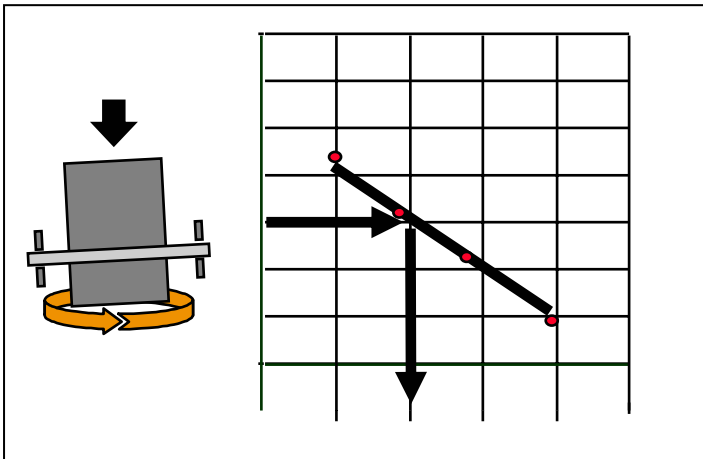
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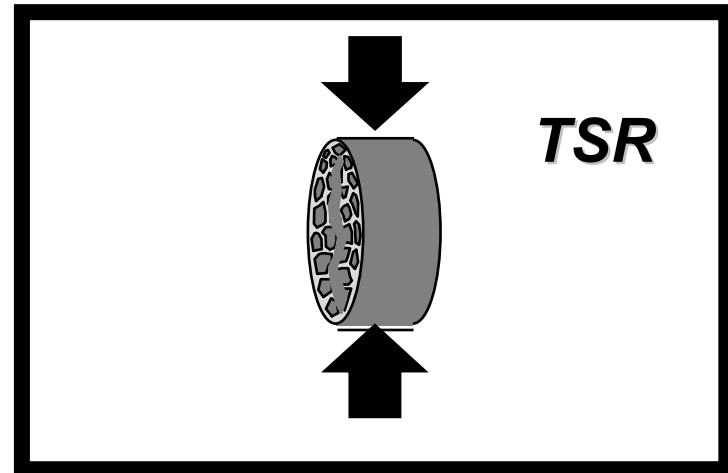
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3. Design Binder Content



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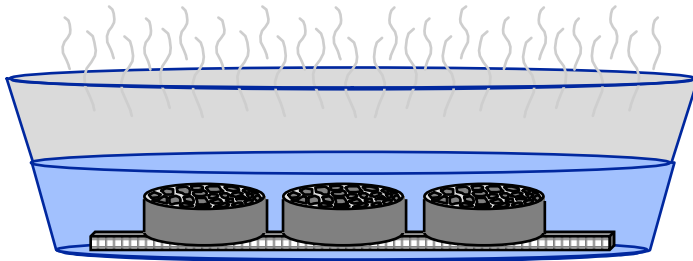
Moisture Sensitivity (AASHTO T 283)

- Prepare set of 6 specimens
 - 6 to 8% voids
- Determine tensile strength of 3 of specimens
- Condition remaining 3 in water bath (60°C, 24 hr.)
 - Option for freeze cycle
- Bring to test temperature (25°C) and determine wet (conditioned) tensile strength

Moisture Sensitivity

- Measured on proposed aggregate blend and asphalt content
- Reduced compactive effort to increase voids

3 Conditioned Specimens



3 Dry Specimens



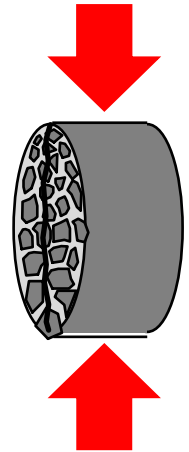
Moisture Sensitivity

Determine the tensile strengths of both sets of 3 specimens

Calculate the Tensile Strength Ratio (TSR)

$$\text{TSR} = \frac{\text{Avg. wet tensile strength}}{\text{Avg. dry tensile strength}}$$

Minimum of 80% needed





Superpave Project Case Histories



First Superpave Mixes on Airfields

- 1998: Little Rock AFB, AR
 - US Air Force
 - Runway Overlay
- 1999: Griffin-Spalding Airport, GA
 - FAA
 - Runway Overlay
 - Airport Manager: “Performance has been outstanding, looking as new as the day it went down.”



North Carolina Division of Aviation Superpave Program

- 2001
 - One Project
- 2002
 - Two Projects
- 2003
 - Six Projects Expected
- Use State Mixes
 - S 9.5 A ($N_{des}=50$) for aircraft <12.5K lbs
 - S 9.5 B ($N_{des}=75$) for aircraft <60K lbs
 - These mixes selected for their impermeability, workability and compatibility.
 - Needed resistance to aging and cracking

An aerial photograph of Volk Field Wisconsin Runway, showing a long, straight runway with a light-colored surface, surrounded by green grass and some trees. The runway is oriented diagonally from the bottom left towards the top right. To the right of the runway, there are several smaller, curved areas of pavement and grass, possibly taxiways or parking areas. In the background, there are more fields and some buildings, including a large white building with a red roof. The overall scene is a mix of natural and man-made elements.

Volk Field Wisconsin Runway

- ANG Runway in 1999
- 1000' overruns and 5800' HMA Interior
- Traffic: F-16s to C-5s
- Used Superpave Mix



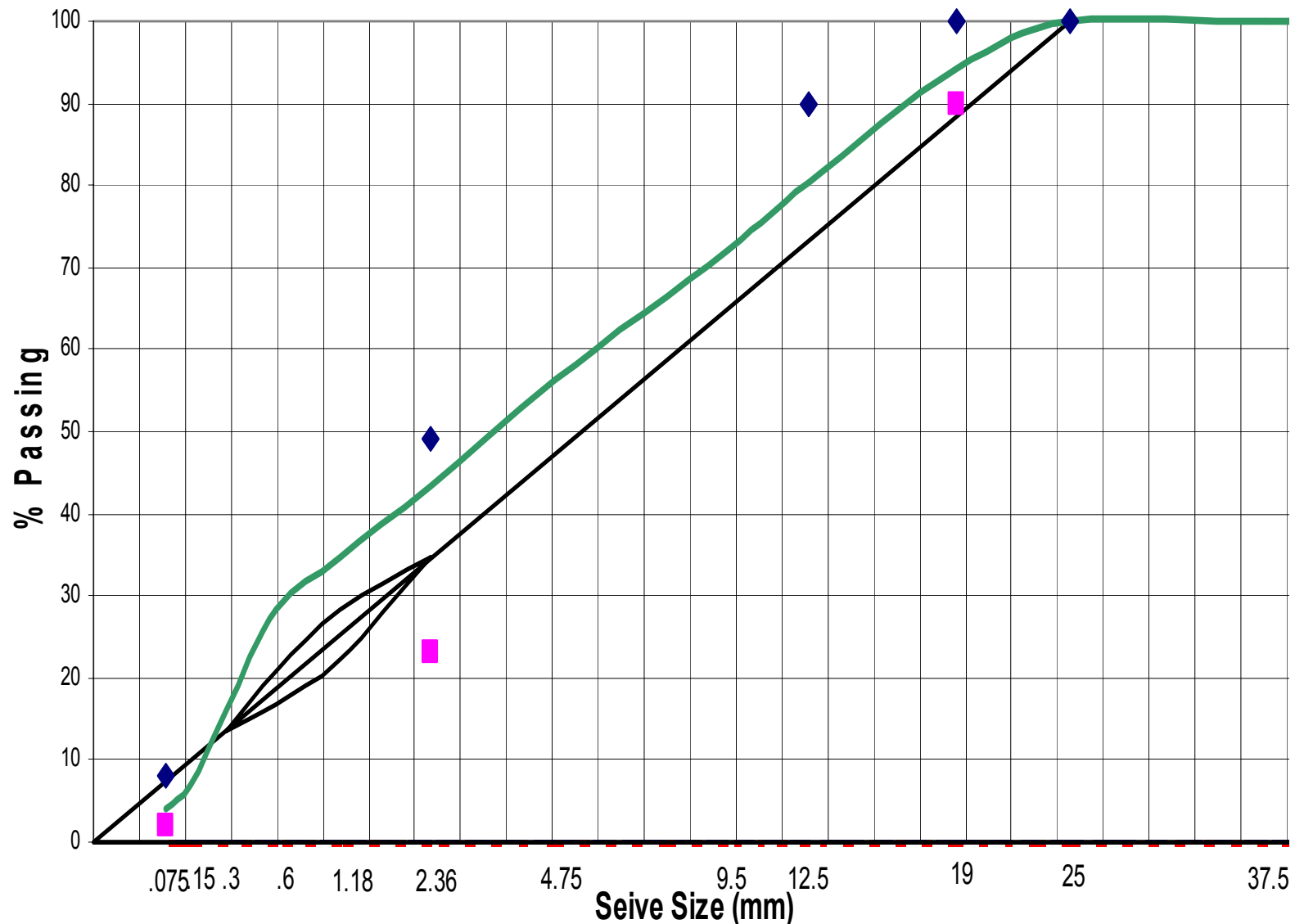
Volk Field HMA Runway Reconstruction

- Base - 3" Lift, 19mm SP, PG 58-28
 - 20% RAP
- Binder – 2" Lift, 12.5mm SP, PG58-28
- Surface – 2" Lift, 12.5mm SP, PG 64-28
 - Modified binder for more durability and resistance to deformation
- Tight Smoothness Tolerances
 - Three Lifts vs Two
 - Topcon Leveling Laser Controls Used In Binder And Surface Lifts
- MTD Used For All Lifts



Volk Field Superpave 19.0 mm Nom Max (PG 58-28)

0.45 Gradation Chart



Paving Surface Lift on Volk Field RW



Volk Field Runway, Fall 2002

No rutting after 4 summers

No cracking after 3 winters





Surface grooves prior to opening



Surface grooves after one year

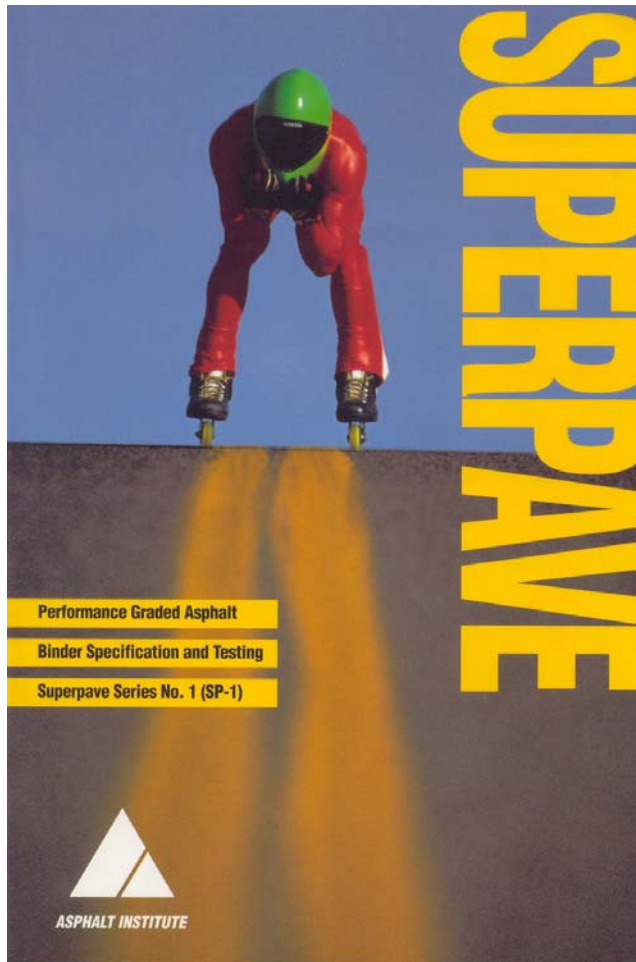


**Surface groves after four summers
and three winters of snow plows**

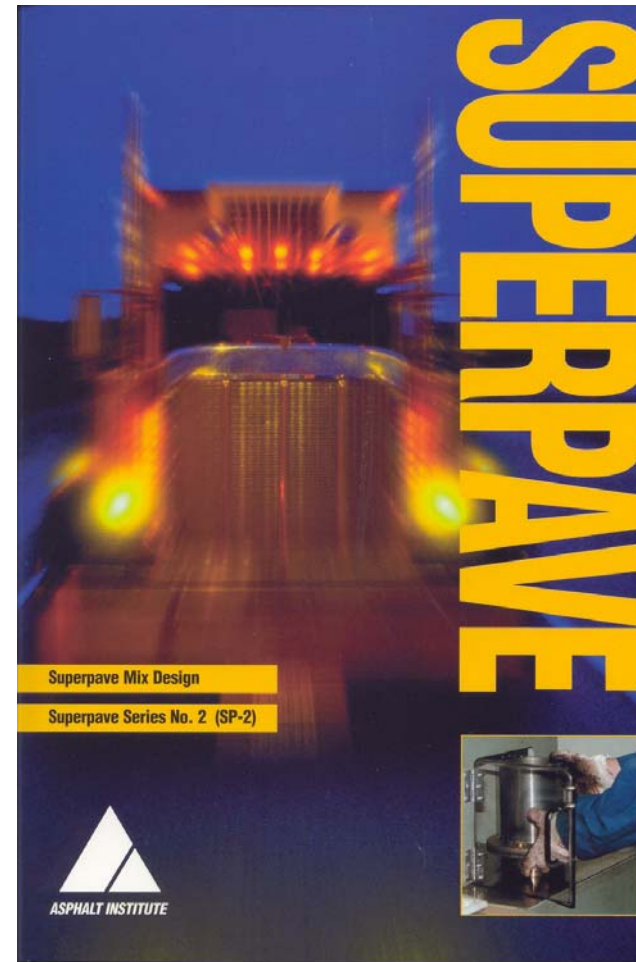
Summary: P-401 vs P-401(SP)

	P-401	P-401(SP)
For Aircraft > 60K lbs	75 Blows	$N_{des}=100$
For Aircraft < 60K lbs	50 Blows	$N_{des}=75$
Design Air Voids, %	2.8-4.2	4.0
Minimum VMA, %	14 (1" MPS)	13 (19mm)
	15 (3/4" MPS)	14 (12.5mm)
Gradation	Dense Fine	Superpave

Superpave Resources



SP-1 Binder Specification



SP-2 Mix Design



FAA/AI Airport Asphalt Pavement 3-day Workshops

- › **Rotate and Partner Among FAA Divisions**
 - **Kansas City, MO - Apr 14-17, 03**
 - **Burlington, MA - July 22-25, 03**
 - **Newport Beach, CA - Nov 4-6, 03**
- › **Airfield Specific Instruction on Thickness
Design, Materials, Specifications, Construction
and Maintenance**
- › **For Airport Agencies, Consultants, Contractors,
Testing Firms**
- › **Averaged 70 Attendees on Last 4 Workshops**

Summary

A large commercial airplane is centered in the background, facing forward. The scene is set at sunset or sunrise, with a warm, orange-yellow glow. The airplane's wings, tail, and engines are visible, though slightly blurred. The overall image has a soft, hazy quality.

- **Superpave is here to stay**
- **FAA EB 59 provides guidance on the use of Superpave at airports in the US**
 - **Superpave PG Binder Selection**
 - **Superpave Mix Design**
- **Several Superpave airfield projects have been completed in the US**
- **The tools are in place for you to succeed on your next Superpave project**



Extra Slides



Airfields are Different than Highways

Airfield Pavements Challenges

- FOD Concerns (for Jets)
- Loading Conditions
 - Gross weights
 - Tire pressures
- Lack of Kneading from Traffic

Deterioration of Airfield Pavements Can Lead to Foreign Object Damage (FOD) of Jet Engines



FOD is a Life-Safety Issue

During the summer of 1996, an F-16 crashed 1.5 miles short of the Pensacola RW while being diverted from Langley AFB due to an expected Hurricane hitting the coast of Virginia. The crash killed a Mother and her small child inside their home. The accident investigation traced the cause of the engine malfunction to a piece of concrete which was ingested back at the Langley airfield.

737-700 Max Gross Weight: 155,000 lbs
Main Gear Tire Pressure: 200 psi



Photo Courtesy Maarten Visser—Technical Data Source: Boeing

Airbus A320 Max Gross Weight: 162,000 lbs
Main Gear Tire Pressure: 200 psi



Photo/Data Courtesy Airbus

777-300ER Max Gross Weight: 750,000 lbs
Main Gear Tire Pressure: 218 psi



Photo Courtesy Andrew Hunt/Airliner.net—Technical Data Source: Boeing

Airbus A340-600 Max Gross Weight: 804,700 lbs
Main Gear Tire Pressure: 228 psi



Photo/Data Courtesy Airbus



747-400ER Max Gross Weight: 910,000 lbs
Main Gear Tire Pressure: 200 psi

MD-11ER Max Gross Weight: 630,500 lbs
Main Gear Tire Pressure: 165 psi



Photo Courtesy American Airlines—Technical Data Source: Boeing

Bombardier Q400: Max Wt 64,500 lbs



Photo/Data Source: Bombardier

Hawker Horizon: Max Wt 37,500 lbs



Photo/Data Source: Raytheon

Beechcraft King Air B-200: Max Wt 12,500 lbs Tire Pressure: 150 psi



Photo Courtesy North Carolina DOT—Data Source: Raytheon

Beechcraft Baron 58: Max Wt 5,500 lbs



Photo/Data Source: Raytheon



F-16C/D Max Gross Weight: 37,500 lbs
but 285 PSI Tire Pressure on Main Gear

C-17 Max Gross Weight: 585,000 lbs
Main Gear Tire Pressure: 138 psi



Photo/Data Courtesy US Air Force



Highway Mixes are Kneaded from Repeated
Loading—Leads to Extended Life



Most airfield pavements are very infrequently loaded—lack of kneading action accelerates aging and leads to “Block Cracking”



Block (Environmental) Cracking on Overrun

Corps of Engineers Guidelines

Aircraft Tire Pressure (psi)	High Temperature Grade Adjustment(s) for Binders
	Pavement Type
	Runways, Taxiways and Parking Aprons
Less than 100	0
100 - 200	0 – 1
Greater than 200	1 – 2

**Unified Facilities Guide Specification
Section 02749 HMA for Airfields**

More General Guidelines

- **PGs above a -22 on the low end (e.g. PG 64-16) are not recommended**
 - May have greater tendency to age prematurely in desert climate and crack
 - Lack of kneading action
- **PG's above a 76 on high end (e.g. 82-22) are not recommended**
 - Stiff and difficult to work/ compact

➤ **Consult with local DOT**